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MASTER'S THESIS

The Impact of Oil Prices on Macroeconomic Indicators in Azerbaijan and Georgia

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Declaration of Authorship

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Prague, June 14, 2015

Signature

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Abstract

Using a multivariate vector autoregression (VAR) approach, this paper investigates the relationships between oil price and macroeconomic indicators of closely interrelated developing economies of oil exporting Azerbaijan and oil importing Georgia based on monthly time series from January 2001 to November 2012. The model is estimated for each country separately and the results are object for comparison. The empirical evidence suggests that oil price has significant effects on macroeconomy in both countries. In particular, these effects are positive for all 3 macroeconomic variables on the example of Azerbaijan. On the example of Georgia, these effects are positive for GDP and inflation rate, and, negative for exchange rate. On the other hand, macroeconomic indicators of Azerbaijan fail to affect oil price level.

JEL Classification	C12, C13, C32, E23, E31, F31, Q43,
Keywords	Oil prices, Macroeconomic indicators, VAR models, Azerbaijan, Georgia

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Acronyms

ADF	Augmented Dickey-Fuller test
BTC	Baku-Tbilisi-Ceyhan pipeline
CPI	Consumer Price Index
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GNP	Gross National Product
HP	Hodrick-Prescott filter
IMF	International Monetary Fund
KPSS	Kwiatkowski–Phillips–Schmidt–Shin test
LM	Lagrange Multiplier
OLS	Ordinary Least Squares
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
OSCE	Organization for Security and Co-operation in Europe
SCP	South Caucasus Pipeline
SOCAR	State Oil Company of Azerbaijan Republic
SOFAZ	State Oil Fund of Azerbaijan
TANAP	Trans Anatolian Pipeline
WB	World Bank
WREP	Western Route Export Pipeline
VAR	Vector Autoregression

Master's Thesis Proposal

Author:	Bc. Farhad Karimov
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Defense Planned:	June 2015

Proposed Topic:

The Impact of Oil Prices on Macroeconomic Indicators in Azerbaijan and Georgia

Topic Characteristics:

High oil price volatility caused by geopolitical uncertainties led to the great concerns about the oil price levels among the policymakers. That was the main reason for a large number of researches conducted on macroeconomic effects of oil price changes. Those researches were aimed to find out whether it is really oil price that influences macroeconomic stability and growth, possible channels of this influence and necessary policy responses. The results of the researches generally conclude that oil prices shocks have significant impact on macroeconomic activity with the following tendency – the larger the shock, the larger the impact. At the same time, different studies have different specifications which allow obtaining more precise results. For example, Melolinna (2012) concludes that also source of the shock matters. Oil demand shocks and oil supply shocks have different effects on macroeconomic indicators. Or, Cunado and Gracia (2003) state that the effect is higher when the national real price index is used instead of the world oil price index. However, the majority of these researches were done in developed economies while only small part was done in the context of developing countries. This paper is going to examine oil price-macroeconomy relationship in Azerbaijan and Georgia.

Hypotheses:

Hypothesis 1. Oil price has positive effect on GDP in Azerbaijan, and opposite in Georgia.
Hypothesis 2. Oil price has positive effect on inflation rate in both countries.
Hypothesis 3. Oil price has positive effect on exchange rate in Azerbaijan, and opposite in Georgia.
Hypothesis 4. GDP, exchange rate and inflation rate in Azerbaijan have no effects on oil price.

Methodology:

This paper studies the impact of oil price volatility on macroeconomic parameters. For econometric analysis of such relationships VAR (Vector Autoregression) model is used. This is the most common method of such estimation, because it generalizes univariate autoregression model by allowing for more than one evolving variable. The following variables are used for this research: average crude oil price, real GDP, exchange rate and CPI. All variables are treated symmetrically in a structural sense and each variable has an equation explaining its own evolution.

Expected contribution:

As it was mentioned, a lot of researches were devoted to examination of the effect of oil price volatility on macroeconomic indicators in developed countries, and not so many in developing ones. This paper is going to provide an insight into oil price and macroeconomic variables relationship in Azerbaijan and Georgia. These countries attract the interest as countries of specific economies in transition. The main advantage of the paper is that it allows for a comparison of macroeconomic effects of oil price between oil exporting country (Azerbaijan) and oil importing country (Georgia).

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Author

Supervisor

1 Introduction

High oil price volatility[1] caused by geopolitical uncertainties led to the great concerns about the oil price levels among the policymakers. A good example is early 2000s recession[2] which was preceded by a sharp increase in oil price. The possible explanations of the recession could be that the rise of oil price decreases Gross Domestic Product (GDP)[3] due to increasing production costs, or, that rising uncertainty caused by oil price shocks leads to delay in business investments. Nevertheless, these concerns were the main reason for a large number of researches conducted on macroeconomic effects of oil price changes using a vector autoregressive (VAR) model.[4] These researches were aimed to find out whether it is really oil price that influences macroeconomic stability and growth, possible channels of this influence and necessary policy responses. Theoretically, an increase in oil price is followed by transfer of revenues from oil importing countries to oil exporting ones. It means that, generally, an oil price increase brings significant gains to the economy of oil exporting countries, even though some part of these gained is further compensated by decreased demand from oil importing trading partners. On the other hand, the reaction of oil importing countries on an increase in oil price is usually negative and mostly depends on the share of cost of oil in national income, on level of dependence on oil imports and on how a country can decrease its oil consumption and switch to other energy sources. The results of the researches generally conclude that oil prices shocks have significant impact on macroeconomic activity with the following tendency – the larger the shock, the larger the impact. At the same time, different studies have different specifications which allow obtaining more precise results. For instance, Melolinna (2012) concludes that also source of the shock

[1] Oil price volatility is the relative rate at which the price of oil varies up and sown. It is usually measured as a standard deviation of changes in oil price. For the details, see Kuper (2002), Narayan (2007) and Regnier (2006).

[2] Early 2000’s recession was the beginning of the Great Recession of 21st century characterized by a downturn in economic activity in developed countries. The impact of the recession was observed mainly in the European Union and the United States.

[3] A measurement of production calculated as the sum of all goods and services produced within a country borders for a certain period of time.

[4] Description of the model is provided in Section 4.

matters. Oil demand shocks and oil supply shocks have different effects on macroeconomic indicators. Or, Cunado and Perez (2003) state that the effect is higher when the national real price index is used instead of the world oil price index. However, the majority of the researches were done in developed oil importing economies while only small part was done in the context of developing oil exporting countries.

This paper is going to provide an insight into oil price and macroeconomic variables relationship in Azerbaijan and Georgia. As well as all the former Soviet republics, both countries experienced the problems of transition from a command economy of Soviet Union to a market economy. The analysis of the paper is based on the estimation of the relationships among oil price, GDP, exchange rate and inflation rate in each country for the sample period between January 2001 and November 2012 using monthly observations. Given the results, the paper also tries to present magnitude and possible transmission channels of the observed effects, in particular, the effects of oil price shocks on macroeconomic indicators in both countries.

Historically, Azerbaijan and Georgia have always maintained strong friendly relations and served as main export-import partners to each other. Both countries are founding members of Organization for Democracy and Economic Development GUAM, members of the Council of Europe and the Organization for Security and Co-operation in Europe (OSCE). Here is a brief overview of the economies of the two countries:

1.1 A brief overview of the economy of Azerbaijan

Azerbaijan has an oil based economy as huge oil reserves are the main contributors to revenues. It is known as one of the first and the most important zones for oil exploration and development in the world.

After the Soviet Union collapse, Azerbaijan suffered a serious economic recession in the period from 1989 to 1994 followed by a significant decrease in GDP by 63%. It needed to start implementing its independent economic policy. In this sense, since Azerbaijan gained its independence, oil and gas industry became the main political and economic object in state policy. It was expected to consolidate territorial integrity, strengthen the independence and ensure future stable economic development inviting huge amounts of foreign investment capital. An important event on the way to recovery after Soviet Union breakup was the 30-year “contract of the century” signed in September 1994 between the State Oil Company of Azerbaijan Republic (SOCAR) and 13 world’s leading oil companies including BP, ExxonMobil, Lukoil and Statoil. This resulted in huge capital inflow to Azerbaijan from abroad and increase in economic development and stability which was observed starting from 1996. After, due to the large number of regulatory and economic measures and actions taken by the President, the national leader Heydar Aliyev, Azerbaijan managed to stand on the path of permanent economic development.

Azerbaijan has always been one of the most industrially developed countries in its region. Because of its economic performance after the Soviet Union collapse, Azerbaijan was named “Tiger of Caucasus”. However, at the same time, its economy was not well diversified because of the slow investments in non-oil sector comparing to huge investments in oil sector. Due to efficient activity of the State Oil Fund of Azerbaijan (SOFAZ), which was established to control the macroeconomic stability, allocation of oil revenues and provision of resources for future generations, investments into non-oil sector increased significantly through the years 2003-2013. Agriculture is the second largest sector in Azerbaijan after energy. Even though it accumulates much lower revenues compared to oil and gas industry, it is responsible for employment of around 50% of the population. Nowadays, huge investments are made in tourism and services sector in order to diversify the economy. Diversification of the economy is very important for Azerbaijan as it will allow to reduce its dependence on oil industry and, also, to decrease its sensitivity to oil price volatility on world markets.

Due to serious political disputes between Azerbaijan and Armenia, Georgia became a major partner for Azerbaijan in implementing projects of oil and gas exports to Europe. These projects were of global importance. As Azerbaijan was not an OPEC or Middle Eastern source of oil and gas, it resulted in diversification of oil and gas supply in the world. After Baku-Tbilisi-Ceyhan (BTC) Pipeline was put in commission in 2006 Azerbaijan has completed the transition to a market economy. This major oil exporting pipeline, which has a capacity of 1 million barrels per day and transports oil from Azerbaijan to the Mediterranean through Georgia and Turkey, is expected to generate about $160 billion until year 2036. That is why high oil prices are highly beneficial for Azerbaijan. It is pertinent to notice that in years 2005-2007 Azerbaijan achieved world’s largest GDP growth (between 26.4-34.6%) due to large spikes in oil prices on world markets and was able to sustain it after. According to Ciarreta and Nasirov (2012), the country's currency reserves have reached 18 billions of US dollars by the end of 2008. Analogous pipeline for the natural gas transportation is Baku-Tbilisi-Erzurum, or, alternatively, South Caucasus, gas pipeline (SCP) – a natural gas pipeline from Azerbaijani gas field Shah Deniz to Turkey through Georgia. It lies parallel to Baku-Tbilisi-Ceyhan oil pipeline. Another giant project - Trans Anatolian Natural Gas Pipeline (TANAP), which will deliver natural gas from Azerbaijan through Turkey to Europe, is now under construction and is planned to be completed in 2019. Due to increase in income and decrease in poverty obtained from large oil revenues, Azerbaijan was able to perform much better than many other countries in terms of global financial crisis.

An option for further development of the economy through the oil and gas transportation to the western countries is building of undersea pipelines projects with Turkmenistan and Kazakhstan. These projects are supported by all 3 countries, however, they can not be implemented until the legal uncertainty and the disputes over the natural sources among the countries bordering the Caspian Sea are solved.

Today, Azerbaijan has 21 production-sharing treaties with different oil companies and is one of the biggest oil suppliers to Europe ensuring the energy security of European Union. The economy of Azerbaijan comprehends around 75-80% of the economy of the whole South Caucasus.

1.2 A brief overview of the economy of Georgia

In the past, Georgia was mainly an agrarian economy. However, today it includes Black Sea tourism (one of the fastest growing sectors), wine, textile and machinery producing, growing of citruses, grapes and tea, and etc.

Like Azerbaijan and other post-Soviet countries, Georgia has suffered a period of serious economic decay after the Soviet Union collapse, characterized by high inflation and budget deficits. International financial institutions, such as International Monetary Fund (IMF) and World Bank (WB), have played an important role in Georgia's economy's recovery. Since 2000, due to multilateral and bilateral loans and grants, Georgia was able to achieve the objective of consistent economic development. In the following years GDP growth remained relatively stable (between 9–12%). Notice that international money transfers from Georgian people working abroad, especially from Russia, comprise an important part of GDP. In 2010, those transfers even exceeded the Foreign Direct Investment (FDI).[5]

Because of the large number of broad economic reforms carried out by previous president, Mikheil Saakashvili, Georgia was named the top reformer in the world by the World Bank in years 2006 and 2008. These reforms, which included anticorruption measures, liberal tax reform, customs reform, simplified labor legislation and administrative procedures, privatization of state property and etc., helped to develop an attractive business environment in Georgia which resulted in massive FDI inflow. At the same time, the reforms diversified the economy and provided sustainable economic growth. Moreover, that is the main reason why Georgia performed so flexible to the war with Russia and global financial crisis.

Georgia imports almost all of natural gas and oil products it needs. It used to purchase natural gas from Russia, before. However, having such an energy rich neighbor as Azerbaijan and direct access to Europe, Georgia took advantage of it to reinforce its geopolitical importance in the region. The opening of the Baku-Supsa oil pipeline in 1999, also known as Western Route Export Pipeline (WREP), the Baku-Tbilisi-Ceyhan oil pipeline in 2005 and the Baku-Tbilisi-Erzurum in 2006 allowed Georgia to reduce its import dependency on Russia and to confirm its strategic location as a transit point of goods between Asia and Europe. Georgia gains significant revenues being a transit country in Caspian Energy Corridor. Transportation of oil by Baku-Tbilisi-Ceyhan pipeline through the territory of Georgia creates additional workplaces in the area of maintenance of the pipeline and other relevant areas, which spurs a decrease in unemployment. Moreover, Georgia does not experience any cost responsibilities considering construction, operation, or maintenance of the pipeline. The importance of Baku-Tbilisi-Erzurum gas pipeline is different for Georgia compared to Baku-Tbilisi-Ceyhan oil pipeline. As mentioned by Omonbude (2012), the country receives percentage (5%) of the gas transported through its territory and has a permission to sell it further. By means of this transition fee Georgia is able to cover a large portion of its energy needs. Additionally, Georgia receives 10% of the gas exports from Russia to Armenia as a transit fee. Due to the conflicts between Russia and Georgia over the Georgian region of South Ossetia in

[5] Foreign Direct Investment (FDI) is an investment of a local entity into foreign economy in order to obtain a lasting interest from that economy.

2008, British Petroleum had to temporarily suspend the oil and gas transportation for safety reasons. The shipment was restored later on. Nowadays, Georgia aims to empower its strategically important geopolitical location by developing partner relationships with Turkmenistan and Kazakhstan.

On the other hand, Georgia has a serious hydroelectric potential. Its hydropower capacity now provides most of its energy needs. Hydro resources give an opportunity for Georgia to control the hydroelectric market and become major electricity exporter in the Caucasus region. There are a lot of new hydroelectric projects considered which would allow Georgia to exploit its whole hydro resource potential and become second-largest hydropower producer in the world.

The econometric analysis in this paper is based on the examination of how oil price changes influence inflation, exchange rate and GDP of these two countries with the help of VAR model. The main advantage of this analysis is that it allows for a comparison of macroeconomic effects of oil price levels between oil exporting country (Azerbaijan) and oil importing country (Georgia). The expected effect of changes in oil price on GDP is going to be positive in oil exporting Azerbaijan and opposite in oil importing Georgia. Trade in value-added approach, which is aimed to estimate the source of value that is added in producing goods and services for export and import, can be used as a support to this intuition. Oil price effect on inflation is supposed to be positive in both countries as oil price increase generates the inflation, overall. Finally, oil price is expected to positively affect the exchange rate in Azerbaijan, and, negatively – in Georgia. That is why the following 4 hypotheses are tested in this paper:

Hypothesis 1. Oil price has positive effect on GDP in Azerbaijan, and opposite in Georgia.

Hypothesis 2. Oil price has positive effect on exchange rate in Azerbaijan, and opposite in Georgia.

Hypothesis 3. Oil price has positive effect on inflation rate in both countries.

Hypothesis 4. GDP, exchange rate and inflation rate in Azerbaijan have no effects on oil price.

The results suggest that oil price has significant effects on macroeconomic indicators in Azerbaijan and Georgia. All of the effects in both countries are observed as expected, except the effects of GDP in Georgia, which appeared to react positively on a shock in oil price. Moreover, the evidence suggests that macroeconomic indicators of Azerbaijan do not have any influence on oil price.

The remainder of this paper is structured as following. Section 2 provides an overview of the previous literature on the actual topic. Section 3 contains the detailed description of data. Section 4 presents the econometric model and empirical framework. Section 5 describes the results of the estimation in details. And, finally, Section 6 summarizes the findings and concludes.

2 Literature Overview

One of the famous energy markets, in particular oil price-macroeconomy relationship, researchers is American econometrician James Douglas Hamilton. In 1983, he discovered that nearly all of the United States recessions were preceded by a sharp increase of the oil price. This argument led to the analysis of the correlation between oil price levels and the output of the United States economy through the sample 1948-1981. He concluded that there is Granger-causality[6] between changes in oil price, on the one hand, and real and nominal Gross National Product (GNP), unemployment, domestic prices, wages, coal and metallic commodity indexes, interest rates and high-grade bond yields, on the other hand. It showed that correlation between oil prices and the macroeconomy is true and statistically significant over 1948-1972, and calls into question the previous assumption of coincidence of this correlation. Hamilton’s further papers on the topic, basically, confirm the existence of significant correlations between oil price and macroeconomy.

Burbidge and Harrison (1984) study the effect of oil prices on macroeconomic indicators, mainly price level and industrial output, using a seven-variable VAR for the 5 OECD countries: the United States, Japan, Germany, the United Kingdom and Canada, during the period 1961-1982. The researchers found out that the effect of oil price shocks on the price level is more significant in the United States and Canada, and less significant in Japan, Germany and the United Kingdom. Moreover, impact on industrial output is more significant in the United States and in the United Kingdom than in the other countries. Another finding showed up after the authors studied the effects of oil price innovations in two different shocks: 1973 and 1979. Burbidge and Harrison discovered that impact of oil price innovations is sizeable for both price level and industrial output after the 1973 shock, and quite weak after 1979 shock.

Gisser and Goodwin (1986), also, provided an analysis of oil price-macroeconomy relationship in the United States. This research confirmed and

[6] Granger causality between the variables implies that information contained in one variable is useful to predict the other variables.

extended Hamilton's results. First, they proved that oil price levels had a significant impact on GDP through the years 1961-1982, and that oil price changes were influenced by exogenous effects. Second, Gisser and Goodwin (1986) were able to distinguish between different oil price determinants before and after 1973. Before 1973, specific regulatory structure[7] in the United States was directed to control the inflation rate. That's why inflation was a main predictor of oil prices during that time. Starting from 1973, after OPEC embargo, no exact variable to predict oil prices was identified.

Mork (1989) discovered that Hamilton's study was based only on the periods of increase in oil price without taking into account the periods of decrease. Thus, the strong correlation between oil prices and economic output were not confirmed for the periods of price decline. In order to overcome this omission, he extended the observable sample to year 1988 including oil price decreases and did the estimation in the same econometrical framework as provided by Hamilton (1983). The results strengthened Hamilton's conclusion about the negative correlation in the periods of oil price increases, as it keeps on with even extended sample. However, the correlations during the oil price declines are totally different and close to zero. This finding crashed Hamilton's assumption about the symmetric effect of oil shocks. So, the effect may also be asymmetric when decrease in oil price is followed by a downturn in economic output.

Mork, Olsen and Mysen (1994) confirmed Mork's conclusion regarding the existence of asymmetric effects in their study of correlation between oil price and GDP in seven OECD (Organization for Economic Co-operation and Development) countries: the United States, Canada, Germany, the United Kingdom and Norway, using quarterly data from 1967 to 1992. There was only one exception represented by Norway. These countries significantly differ in an extent to which their economies depend on oil. The results showed that the correlations with increases in oil price are negative and significant for all countries, again, except Norway, as its oil sector represents the hugest part of the whole economy. The correlations with decreases in oil price appeared positive for all, but significant only for Canada and the United States.

[7] The oil pricing in the United States was regulated by the authorities whose supply-demand manipulation was restricted by keeping inflation under control.

Hooker (1996) concentrated on the OPEC's (Organization of the Petroleum Exporting Countries) oil price shocks of 1973 and 1979. He observed that Granger causality between oil prices and macroeconomy no longer exists starting from 1973 and provided several possible explanations for that, such as importance of the sample stability, endogeneity of the oil prices, misspecification and etc. The most important discovery of the research was that oil price shock of 1973 had a big and substantial effect on macroeconomy, while the shock of 1979 was significant but not complete to catch the dynamics of subsequent recession.

Extending the works of Hamilton (1983), Gisser and Goodwin (1986) and others, Ferderer (1996) showed that not only oil price increases, but also oil price volatility matters for negative impact on macroeconomy. Oil price shocks increase oil price volatility, which was empirically proved, in this paper, to help in prediction of aggregate output movements in the United States. The sample size used for the estimation was from 1970 to 1990 collected monthly. The estimation also included monetary variables, but the results showed that these variables had much less significant effect than oil price variables. Thus, they were not able to explain the previously found asymmetric effects. Ferderer (1996) gave an explanation for these asymmetries in oil price-macroeconomy relationship as economy's reaction to oil price volatility.

Papapetrou (2001) studied the effects of oil price shocks on financial markets and real economic activity on the example of the medium-sized economy of Greece. In particular, this paper analyzed the relationships among oil prices, real stock prices, interest rates, real economic activity and employment in a multivariate VAR model. The advantage here is that the paper uses both industrial production and employment in 2 different model specifications for measuring the economic activity, which allows obtaining of dynamic interactions among the chosen variables. Another point is that Greece is an oil importing country and it imports almost 80% of its total energy needs. The model has been estimated using monthly data for the sample period from 1989 to 1999. As a result, both model specifications suggest that an oil price shock and an interest rate shock has a significant negative effect on economic activity (industrial production and employment) in Greece. The responses of stock prices to an oil price shock are also significantly negative in both models. The reaction of industrial production and employment to a shock in real stock prices is negative indicating that stock price increase does not necessarily stimulate growth in economic activity. Also, the impact of a shock in interest rate on real stock prices appeared to be negative.

Cunado and Gracia (2003) analyze macroeconomic consequences of oil price changes using Granger causality and structural stability tests[8] in many European countries in sample period 1960-1999 using quarterly data. Four different proxies for oil price were used by the authors for precise measurement of the impact of oil price changes on inflation rate and industrial output. The study found that the effects of oil price on inflation and output are different depending on which proxy is used (e.g. the effects with national oil price measured in national currency are higher than with world oil price, because of the impact of exchange rates on the macroeconomic variables). Moreover, due to the use of different proxy variables for the oil price authors also established the asymmetric effects of oil price on macroeconomy. The results also suggest that effects of oil price shocks are short-run. Authors did not find any evidence for the support of long-run relationship. In the analysis of short-run relationship oil price appeared to Granger cause output growth rate. Another important conclusion of the paper is that oil price shocks influence the economic activity not only through inflation rate but also by means of the different instruments, while oil price was found to Granger-cause economic activity even after inflation variable was included into regression. Finally, during the analysis authors recorded the different effects of oil prices among the countries (e.g. vulnerable growth rate of production in Luxemburg, different inflation rate responses in Italy and etc.)

Similar work was done by Cologni and Manera (2005) who tried to estimate the direct impact of oil prices on macroeconomic indicators and empirically verify if exogenous oil price shocks were transmitted to the central banks' monetary policy actions in G-7 countries using VAR model with quarterly data during sample period 1980-2003. The results showed that an unexpected oil price shock leads to a raise of inflation rate and fall of output growth. Central banks in most of the countries decided to increase the interest rate and fight the inflation. Monetary authorities in other countries, on the contrary, lowered the interest rate in order to reduce the impact of the oil price shocks on growth rate of the output. Also, their results propose

[8] Examples of structural stability tests are: Chow test for structural breaks, Wald test and Lagrange multiplier test for the true value of parameters and etc.

that a substantial part of these impacts is affected indirectly by the monetary policy responses.

Another paper studying the effect of oil price shocks on real economic activity in OECD countries is the work by Jimenez-Rodriguez and Sanchez (2005) who use the quarterly data for the sample period from 1972 till 2001. The research was conducted based on both linear and non-linear models in a multivariate VAR. The estimation provides an evidence of non-linear relationship between oil price and real GDP, as oil price increases appear to have greater effect than oil price decreases. The authors also showed that environment in which oil price is changing matters as well. The effects in stable price environment are larger than those in volatile price environment. That's why it is important to control for time-varying variability of the oil prices. Another distinctive feature of the study is that it analyzes the relationship of interest in oil exporting and oil importing countries. Notable here is that among oil exporting countries Norway benefits from the oil price raise, while the United Kingdom has negative effects on the economy. Authors explain that in terms of sharper real exchange rate appreciation in the United Kingdom. Regarding the oil importing countries, Japan is the country that is found to benefit from the oil price increases. This fact is justified by specific environment present in Japanese economy during the observable period. Japan's economy appeared to be very flexible to the shocks of 1970's and early 1980's and reacted positively to oil price increases due to extremely high economic growth in that period. However, after 1980's, the country was not able to benefit from the oil price decreases as it was exercising an economic decay.

An analysis of the relationships between oil price and macroeconomic indicators in Nigeria employing VAR model was presented by Akpan (2009). The study is of interest as Nigeria is highly dependent on crude oil export earnings while it constitutes about 90% of total export revenues. The author uses data sample for the period from 1970 until 2007 on quarterly basis in order to capture first and second oil price booms in the period of 70s and middle of 2000s, respectively. The variables representing macroeconomic indicators of Nigeria are as follows: real industrial production, real effective exchange rate, real public expenditure and inflation. The results of empirical estimation indicate abnormal negative effects of oil price shocks on the oil exporting economy of Nigeria throughout the whole sample period. This impact was explained by instability of Nigerian economy and its high dependence on imports. A strong need in stabilizing macroeconomic structure of Nigerian economy by policymakers was marked in the conclusion of the paper.

Miller and Ni (2010) used a decomposition of the traditional oil price changes variable into forecasted long-term average of discounted oil price and changes in unanticipated deviations of oil prices in their analysis of the oil price-macroeconomy relationship. The authors used quarterly data for the sample period 1971-2008. The results indicated that the two components of decomposition have different impacts on the future GDP growth. The forecasted long-term average appeared to have more significant effects on GDP than unanticipated deviations, first, because forecast of the average fuel price is the main predictor of the demand for gasoline powered transportation equipment, and, second, an increase in price of imported oil results in negative impact on income. The estimates showed that the forecasted long-term average of oil prices had a serious negative effect on GDP growth in the 2000's. However, previously studied asymmetric effects of oil price changes on macroeconomic indicators were found to be captured by unanticipated deviations in oil prices, where the size of the deviations matters.

An example of the oil price-macroeconomy relationship analysis in the context of developing countries is paper by Ito (2010) empirically studying macroeconomic impacts of oil price volatility in Russia, as a world's second largest oil exporting country, using quarterly data for sample period 1994-2009 and VAR model. The results confirm the asymmetric effects and show that a raise (fall) in oil price is followed by increase (decrease) in GDP and inflation rate, and by depreciation (appreciation) of exchange rate.

An attempt to study the impacts of an oil price hike on macroeconomic activity in Belarus using co-integrated VAR model was performed by Ito (2010). The model was estimated with exports of goods, inflation rate, real GDP and real oil price based on quarterly data from the first quarter of 1996 to the second quarter of 2008. The results of estimation suggest that an oil price shock has a positive effect on Belarusian GDP in long run with almost no effect in short run, a positive effect on exports of goods and a negative effect on inflation in preceding periods. These effects were explained by specific political relations of Belarus with Russia.

Du, He and Wei (2010) performed an analysis of oil price-macroeconomy relationships in a multivariate VAR model for China which is the 2nd largest oil consumer in the world after the US, highly dependent on imported oil supply and has a market-oriented domestic mechanism of oil pricing. The sample period used in the paper is from 1995 to 2008 based on monthly observations. The authors used real GDP, inflation, money supply and interest rate as indicators of macroeconomic activity. Besides Granger causality tests, impulse responses analysis and variance decomposition, authors also account for structural stability testing in both linear and non-linear models. The results, first, indicate that there is a structural break in 2002 when the reforms in domestic oil pricing mechanism were adopted. Before the break, no significant effect of oil price on macroeconomic indicators of China was observed. However, after the break, this effect becomes significant and positive. The positive effect of oil price on Chinese economy was unexpected as China is an oil importing country. The authors made an effort to connect these effects with close connection of Chinese export to the US and the EU market which have the influential power on oil price level. Finally, Granger causality tests demonstrated that macroeconomic indicators of China do not appear to have an impact world oil price.

Likewise, Gozali (2011) analyzed the impact of oil price volatility and oil price levels on macroeconomic activity of Indonesia using quarterly data for two periods: 1990-2008 and 1999-2008. The structural break in the data was observed during the Asian Financial Crisis.[9] The results of both data sets indicate that oil price volatility appears to substantially influence the economic activity only when the variable for oil price levels is included into VAR estimation. Moreover, oil price levels have significant effects on government consumption and investment, and this effect is higher when realized volatility rather than historical volatility is used in the estimation.

Real business cycle model introduced by Plante and Traum (2012) was used to study the relationship between oil price volatility, on the one hand, and output, consumption and investment, on the other hand, for the case of the United States with the help monthly data during sample period 1986-2011. The advantages of this model are: 1) it accounts for both firm oil demand, as for an input, and household oil demand, as for a good, 2) it allows to capture the effects of oil price uncertainty, 3) it allows for non-linear solution. The results suggest that, first, an increase in oil price

[9] The crisis that started in July 1997 in Thailand and characterized mainly by currency devaluations and other consequences mostly affected Thailand, South Korea and Indonesia.

volatility leads to a decrease in consumption, second, decrease in consumption positively affects precautionary savings motives, and, third, precautionary savings motives stimulate an increase in investment and GDP.

Studying how oil price shocks affect macroeconomy in the United States based on monthly data from 1974 to 2010, Melolinna (2012) provided a six-variable oil market VAR estimation for the United States using new measurement of oil demand as compared to previous studies. An important extension of the model is that it takes into consideration both demand and supply shocks, and monetary policy shocks. This extension helps to get more precise results regarding the effects of oil price shocks. The results of the paper suggest that oil demand shocks and oil supply shocks have different effects on economic activity. In particular, positive oil demand shocks appeared to positively influence GDP in the United States, while oil supply shocks had a vice versa effects. As opposite to the previous studies on the topic, this paper found that oil price shocks are not the important drivers of the economic activity. Domestic macroeconomic shocks had more sizeable effects on macroeconomic indicators.

Jo (2012) studied the effects of oil price uncertainty on global real economic activity, where the uncertainty was measured as time-varying standard deviation of oil price forecasting error, and global real economic activity was measured as industrial production index. The data sample used by the authors is mainly from 1947 to 2008 treated on quarterly, monthly and daily basis. The uncertainty was represented as stochastic volatility process and was included into VAR estimation, what helps to investigate its impact on economic activity more precisely. Also, the use of stochastic volatility allows to separate first and second moment effects in the statistical framework. This type of modeling turned out beneficial as it gave a possibility to obtain realized volatility as additional oil price uncertainty indicator. The main result of the paper showed that oil price uncertainty has a persistent substantially negative effect on global economic activity. Generally, the findings of the paper once more confirm that it is important to account for oil price uncertainty while implementing monetary policy actions.

Based on the wide range of literature reviewed Ebrahim, Inderwildi and King (2014) concluded that high oil price volatility has damaging and destabilizing effects on economic activity and impedes the economic growth. To provide stable future economic growth the combination of demand-side and supply-side policies concerning solution to oil price volatility is crucial.

Another paper exploiting VAR model for analysis of oil price-macroeconomy relationships in developing country is Ghosh and Kanjilal (2013) written on India for the sample period 1991-2009 using monthly data. The authors found that oil prices are exogenous to macroeconomic activities in India. Also, the study confirms the asymmetric effects of oil price shocks and the fact that negative oil price shocks have stronger impact compared to positive ones.

3 Data

The variables included into the model are the following:

- Average crude oil price measured in national currency[10] of each country – *“oil_price_aze”*, *“oil_price_geo”*
- Real GDP measured in national currency of each country – *“rgdp_aze”*, *“rgdp_geo”*
- Exchange rate as period average of official exchange rate measured in amount of the US dollars per unit of national currency of each country – *“er_aze”*, *“er_geo”*
- Inflation rate measured as consumer price index[11] for each country (CPI, 2005=100) – *“cpi_aze”*, *“cpi_geo”*

Data for the average crude oil price, nominal GDP and exchange rate was extracted from International Monetary Fund (IMF) Database (International Financial Statistics), where it is available monthly, except GDP which is available on quarterly basis at most. The data for inflation rate was extracted from World Bank (WB) Database (Global Economic Monitor), where it is available on monthly basis. Data frequency for the estimation was considered monthly in order to get more precise results. That’s why monthly values for the GDP were interpolated from the quarterly data of International Monetary Fund Database using quadratic-match average function – practically useful technique of low frequency data interpolation to fill in the high observations. Based on Ito (2010), in order to obtain real GDP values, nominal GDP was deflated by CPI for each country as an alternative for GDP deflator. This method was employed because the data for GDP deflator and real GDP is not available for the frequency higher than annual. Data for the average crude oil

[10] National currency of Azerbaijan – Azerbaijani manat (AZN); national currency of Georgia – Georgian lari (GEL)

[11] A measurement of oil price levels computed as weighted average of the prices of market basket of consumer goods and services including food, transportation and medical care.

price in IMF Database was measured in the US dollars. It was converted into national currency of each country according to period average of the official exchange in each country, respectively. Data for the exchange rate in IMF Database was measured as amount of national currency per the US dollar. It was transformed to the form of amount of the US dollars per unit of national currency using simple arithmetical technique for better interpretation.

The empirical estimation in this paper is based on the sample period from 2001:M1 to 2012:M11. It was decided to work within this period because the data for the period of existence of the Soviet Union is unavailable and the data for the first several years of independence after the Soviet Union collapse is characterized by economic chaos. Starting from 2001, the countries already finished the process of recovery and were able to stabilize their economies. The sample period after November 2012 was not employed, again, because of unavailability of the data.

4 Econometric model

The theory suggests that no method is ex ante better than another one. However, from an empirical perspective follows that for econometric analysis of the relationships between oil price volatility and macroeconomic indicators VAR model is applicable. This is the most common method of such estimation, because it generalizes univariate autoregressive model by allowing for more than one evolving variable. The following 4 variables are used in this research: average crude oil price, real GDP, average of the official exchange rate and inflation rate as CPI in levels. All variables in this four-variable VAR model are treated symmetrically in a structural sense and each variable has an equation explaining its own evolution.

The methodology of this study implies a simple reduced-form VAR model proposed by Sims (1980):

$$X_t = \mu + \sum_{i=1}^{p-1} A_i X_{t-i} + \varepsilon_t; \qquad \varepsilon_t \sim i.i.d.(0, \Omega) \tag{4.1}$$

where X_t is a $(n \times 1)$ vector of the variables, μ is a $(n \times 1)$ vector of intercept terms, A_i is a $(n \times n)$ matrix of coefficients, n is the number of variables, p is the number of lags, ε_t is a $(n \times 1)$ vector of the error terms with $t = 1, 2, \ldots, T$. Furthermore, ε_t is independently and identically distributed (i.i.d.) with zero mean $(E(\varepsilon_t) = 0)$ and a $(n \times n)$ symmetric variance-covariance matrix Ω $(E(\varepsilon_t \varepsilon_t') = \Omega)$. The model is estimated for each country separately and the results are the object for comparison. The model estimating the relationships between average crude oil price and macroeconomic indicators of Azerbaijan is denoted as Model 1. The model estimating the relationships between average crude oil price and macroeconomic indicators of Georgia is denoted as Model 2.

In order to correctly specify a VAR model, first, it is necessary to choose an optimal number of lags for the estimation. To identify the optimal lag order model should be first estimated using ordinary least squares (OLS)[12] method for a finite range of lag orders. The optimal number of lags for a model is usually selected by minimizing one of the following information criteria: Akaike Information Criterion, Hannan-Qiunn Criterion, Schwarz Criterion, Final Prediction Error. In this paper, an optimal lag order for initial specifications of the models was selected equal to 2 ($p = 2$) based on the Schwarz Criterion, or, as an alternative name, Bayesian Information Criterion, for both models. The formula for Schwarz Criterion is as follows:

$$\mathrm{SC}(p) = \log\det\left(\tilde{\sum}(p)\right) + \frac{\log T}{T} \times p \times K^2 \qquad \textbf{(4.2)}$$

where p is a lag order of the model, $\det(\sum^{\sim}(p))$ is the determinant of the estimated noise covariance matrix, T is a sample size and K is time series dimension.

4 variables in both models are ordered in the following way: first comes average crude oil price, second is real GDP, third – exchange rate, and, the last, fourth – inflation rate.

Moreover, the central assumption in this paper is that the macroeconomic indicators of Georgia do not affect the world average crude oil price level as Georgia is neither oil producer nor oil exporter. In other words, variable *"oil_price_geo"* is assumed as exogenous in Model 2. That is the reason why the estimation is done using a restricted VAR model with the corresponding subset restrictions applied to the matrix of coefficients. After implementing these restrictions, the initial equation and the matrix of coefficients in Model 2 look as follows:

[12] A method of estimating linear regression models based on minimization of the sum of squared residuals. For the details see Stock and Watson (2007).

$$\begin{pmatrix} oil\_price\_geo(t) \\ rgdp\_geo(t) \\ er\_geo(t) \\ cpi\_geo(t) \end{pmatrix} = \begin{pmatrix} \alpha_{11} & 0 & 0 & 0 \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} \end{pmatrix} \times \begin{pmatrix} oil\_price\_geo(t-1) \\ rgdp\_geo(t-1) \\ er\_geo(t-1) \\ cpi\_geo(t-1) \end{pmatrix} +$$

$$\begin{pmatrix} \beta_{11} & 0 & 0 & 0 \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \\ \beta_{41} & \beta_{42} & \beta_{43} & \beta_{44} \end{pmatrix} \times \begin{pmatrix} oil\_price\_geo(t-2) \\ rgdp\_geo(t-2) \\ er\_geo(t-2) \\ cpi\_geo(t-2) \end{pmatrix} + \begin{pmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \end{pmatrix} \times (CONST) + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{pmatrix}$$

As opposed to Model 2, all of the variables in Model 1 are assumed as endogenous. Therefore, no restrictions are applied as Azerbaijani macroeconomic indicators are expected to somehow affect world average crude oil price. That is why the model is estimated using unrestricted VAR model. The initial model equation and the matrix of coefficients, in this case, look as follows:

$$\begin{pmatrix} oil\_price\_aze(t) \\ rgdp\_aze(t) \\ er\_aze(t) \\ cpi\_aze(t) \end{pmatrix} = \begin{pmatrix} \delta_{11} & \delta_{12} & \delta_{13} & \delta_{14} \\ \delta_{21} & \delta_{22} & \delta_{23} & \delta_{24} \\ \delta_{31} & \delta_{32} & \delta_{33} & \delta_{34} \\ \delta_{41} & \delta_{42} & \delta_{43} & \delta_{44} \end{pmatrix} \times \begin{pmatrix} oil\_price\_aze(t-1) \\ rgdp\_aze(t-1) \\ er\_aze(t-1) \\ cpi\_aze(t-1) \end{pmatrix} +$$

$$\begin{pmatrix} \theta_{11} & \theta_{12} & \theta_{13} & \theta_{14} \\ \theta_{21} & \theta_{22} & \theta_{23} & \theta_{24} \\ \theta_{31} & \theta_{32} & \theta_{33} & \theta_{34} \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} \end{pmatrix} \times \begin{pmatrix} oil\_price\_aze(t-2) \\ rgdp\_aze(t-2) \\ er\_aze(t-2) \\ cpi\_aze(t-2) \end{pmatrix} + \begin{pmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \\ \varphi_4 \end{pmatrix} \times (CONST) + \begin{pmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \end{pmatrix}$$

The whole estimation includes unit root tests, structural stability tests, tests for autocorrelation in residuals, Granger causality tests, formulation of impulse response functions and variance decomposition.

5 Empirical results

5.1 Unit root tests

In time series analysis central role belongs to the assumption that the series is stationary, that is its mean, variance, and autocorrelation structure do not change with time.

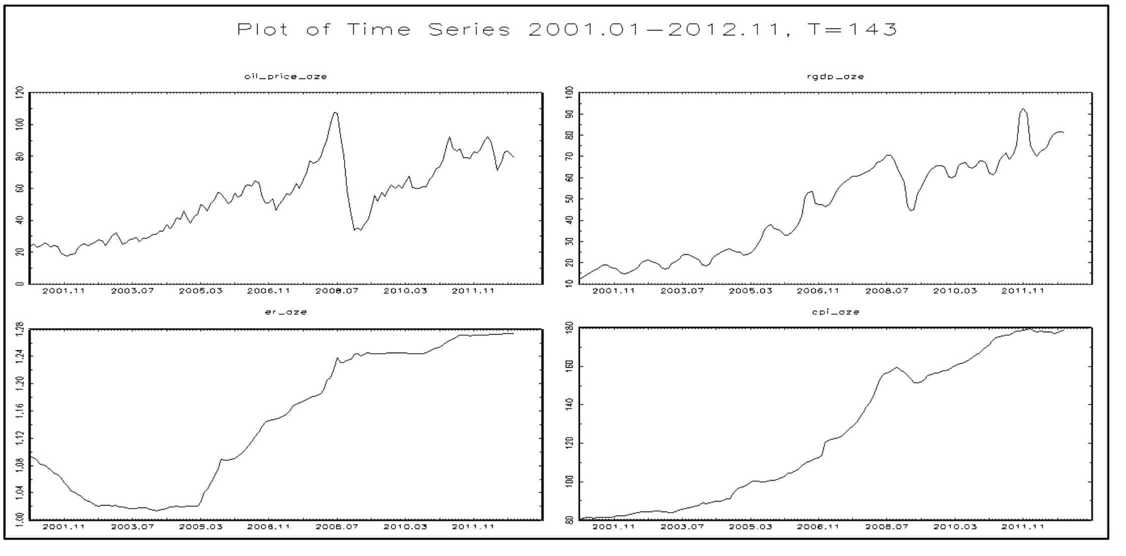

Figure 5.1.1: Plot of the time series of Azerbaijan

Source: author's computations.

From the time series plot of both datasets, for Azerbaijan and Georgia, it is visible that the series behavior does not imply stationarity, i.e. constant mean and constant variance are not observed throughout the sample period (See Figure 5.1.1 and Figure 5.1.2).

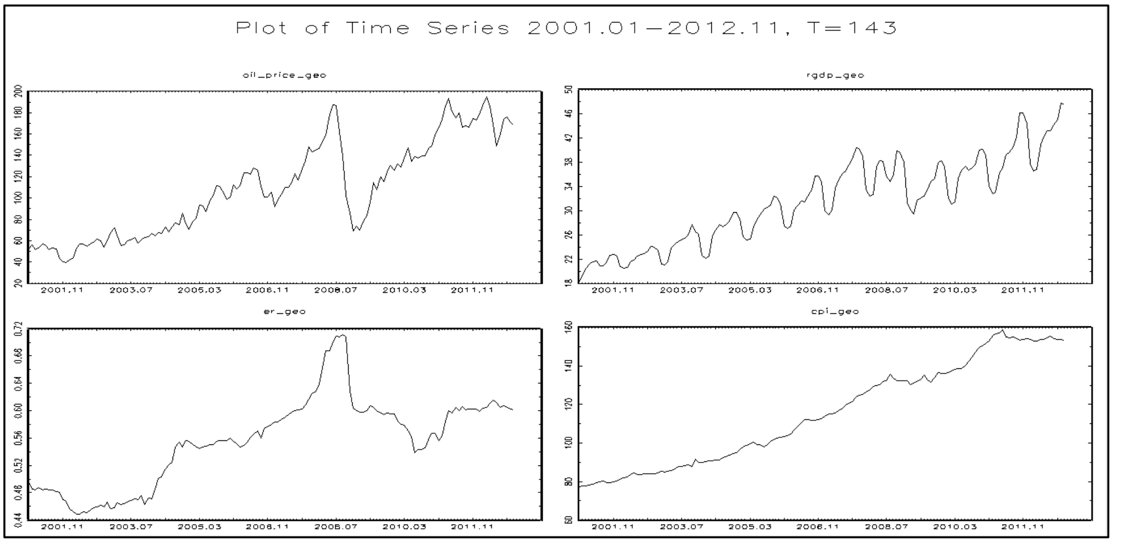

Figure 5.1.2: Plot of the time series of Georgia

Source: author's computations.

To check exactly whether the series are stationary or not, commonly two basic tests are used: Augmented Dickey-Fuller (ADF) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. ADF test tests for the null hypothesis that the series has a unit root, i.e. it is non-stationary, against the alternative hypothesis that the series is stationary. On the contrary, the null hypothesis in KPSS test stands for stationarity of data generating process, and, alternative hypothesis stands for the presence of unit root in the series. Each series in both datasets, Azerbaijani and Georgian, were tested separately using both of these tests. The results of ADF test claim that the null hypothesis of unit root presence can not be rejected at 1%, 5% and 10% significance level indicating that all of the series are non-stationary.

Table 5.1.1: The results of the unit root tests for the time series of Azerbaijan

Test	Variable	Test statistic	Stationary
ADF	*"oil_price_aze"*	-0.2642	No
KPSS	*"oil_price_aze"*	3.5496	No
ADF	*"rgdp_aze"*	0.6850	No
KPSS	*"rgdp_aze"*	4.5832	No
ADF	*"er_aze"*	1.5571	No
KPSS	*"er_aze"*	4.5069	No
ADF	*"cpi_aze"*	2.5977	No
KPSS	*"cpi_aze"*	4.7843	No

Source: author's computations.

Furthermore, the KPSS test has confirmed the results of ADF test showing that null hypothesis of stationarity is rejected at the same three levels of significance (See Table 5.1.1 and Table 5.1.2). To overcome non-stationarity problem in time series logarithmizing and first differencing techniques are frequently used. However, a more important condition for VAR process, which is the case in this paper, is structural stability of the whole model rather than stability of each variable and it is tested further.

Table 5.1.2: The results of the unit root tests for the time series of Georgia

Test	Variable	Test statistic	Stationary
ADF	*"oil_price_geo"*	0.0430	No
KPSS	*"oil_price_geo"*	3.9227	No
ADF	*"rgdp_geo"*	0.5779	No
KPSS	*"rgdp_geo"*	4.2170	No
ADF	*"er_geo"*	0.5025	No
KPSS	*"er_geo"*	3.2645	No
ADF	*"cpi_geo"*	3.7664	No
KPSS	*"cpi_geo"*	4.8390	No

Source: author's computations.

5.2 Structural stability analysis

Structural stability basically indicates that the VAR process will not diverge to infinity. What is very important, that stability of the VAR process also implies its stationarity. That is why one can turn a blind eye to non-stationarity of single series if the whole sample is stable. Structural stability is examined using eigenvalues of the matrix of coefficients. The process is defined stable if the eigenvalues are less than $|1|$ which means that inverse roots of characteristic polynomial are inside the unit circle. If the eigenvalues are equal to more than $|1|$, or, if the inverse roots lie outside the unit circle, then VAR process appears to be non-stable. Moreover, structural stability can be investigated using CUSUM test. It calculates cumulative sum of recursive residuals for certain period and plots it together with confidence intervals. If the plot varies within the confidence intervals and tends to converge to zero in a long run, this is evidence of stability of the process. And, respectively, if the plot falls beyond the confidence intervals and goes to infinity, stability is rejected.

5.2.1 Structural stability analysis for Azerbaijan

From the inverse roots analysis of initial specification of Model 1 with lag order equal to 2 based on Schwarz Criterion it is obvious that the whole sample is unstable as not all eigenvalues of the matrix of coefficients are less than |1| and at least one inverse root lies outside the unit circle (See Figure 5.2.1.1 and Table 5.2.1.1).

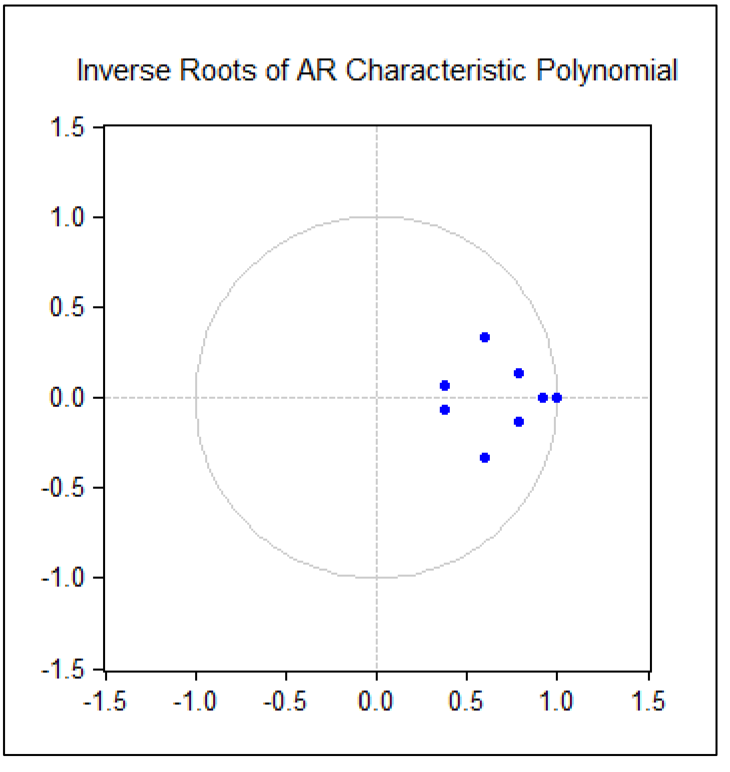

Figure 5.2.1.1: AR roots graph for Model 1

Source: author’s computations.

Table 5.2.1.1: AR roots table for Model 1

Roots of Characteristic Polynomial
Endogenous variables: OIL_PRICE_AZE RGDP_AZE ER_AZE CPI_AZE
Exogenous variables: C
Lag specification: 1 2

Root	Modulus
1.000935	1.000935
0.922531	0.922531
0.789809 - 0.134395i	0.801162
0.789809 + 0.134395i	0.801162
0.598505 - 0.332860i	0.684838
0.598505 + 0.332860i	0.684838
0.380752 - 0.063042i	0.385936
0.380752 + 0.063042i	0.385936

Warning: At least one root outside the unit circle.
VAR does not satisfy the stability condition.

Source: author's computations.

The results of CUSUM test confirm the structural unstability of initial specification of Model 1 while cumulative sum of recursive residuals plot for the equation of exchange rate falls beyond its confidence interval (See Figure 5.2.1.2).

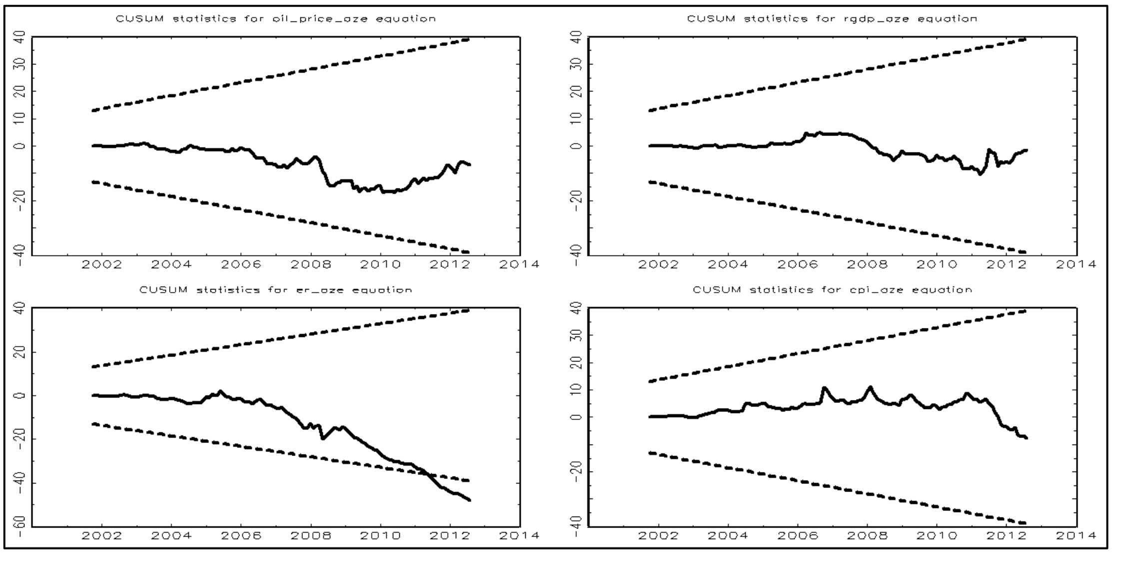

Figure 5.2.1.2: CUSUM statistics for Model 1

Source: author's computations.

In order to solve the stability problem, the technique of first differencing the data was applied. First difference of the time series is simply the change of one period from the previous one and has the following representation:

$$\Delta y = y_t - y_{t-1} \tag{5.1}$$

The newly obtained variables are as follows: *"oil_price_aze_d1"*, *"rgdp_aze_d1"*, *"er_aze_d1"*, *"cpi_aze_d1"*. This specification of the model is denoted as Model 1 with first differences.

Inverse roots analysis of Model 1 with first differences with lag order equal to 1 based on Schwarz Criterion for this specification indicates that the sample is stable as all eigenvalues of the matrix of coefficients are less than |1| and inverse roots lie inside the unit circle (See Figure 5.2.1.3 and Table 5.2.1.2).

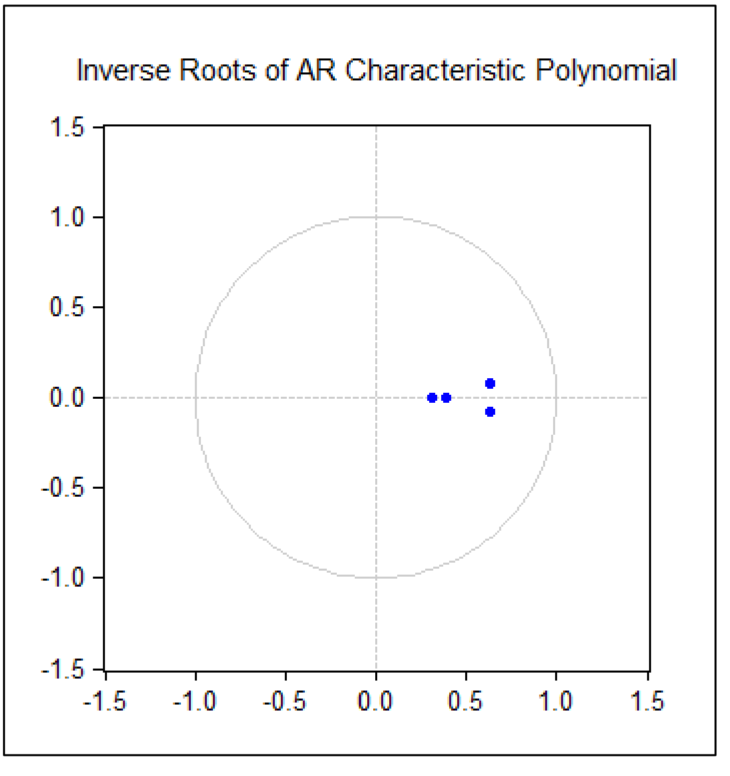

Figure 5.2.1.3: AR roots graph for Model 1 with first differences

Source: author's computations.

Table 5.2.1.2: AR roots table for Model 1 with first differences

Roots of Characteristic Polynomial
Endogenous variables: D(OIL_PRICE_AZE) D(RGDP_AZE) D(ER_AZE) D(CPI_AZE)
Exogenous variables: C
Lag specification: 1 1

Root	Modulus
0.634888 - 0.080324i	0.639949
0.634888 + 0.080324i	0.639949
0.390087	0.390087
0.309316	0.309316

No root lies outside the unit circle.
VAR satisfies the stability condition.

Source: author's computations.

The results of CUSUM test confirm the structural stability of the model this time while cumulative sum of recursive residuals plot for each series wanders within its confidence intervals (See Figure 5.2.1.4).

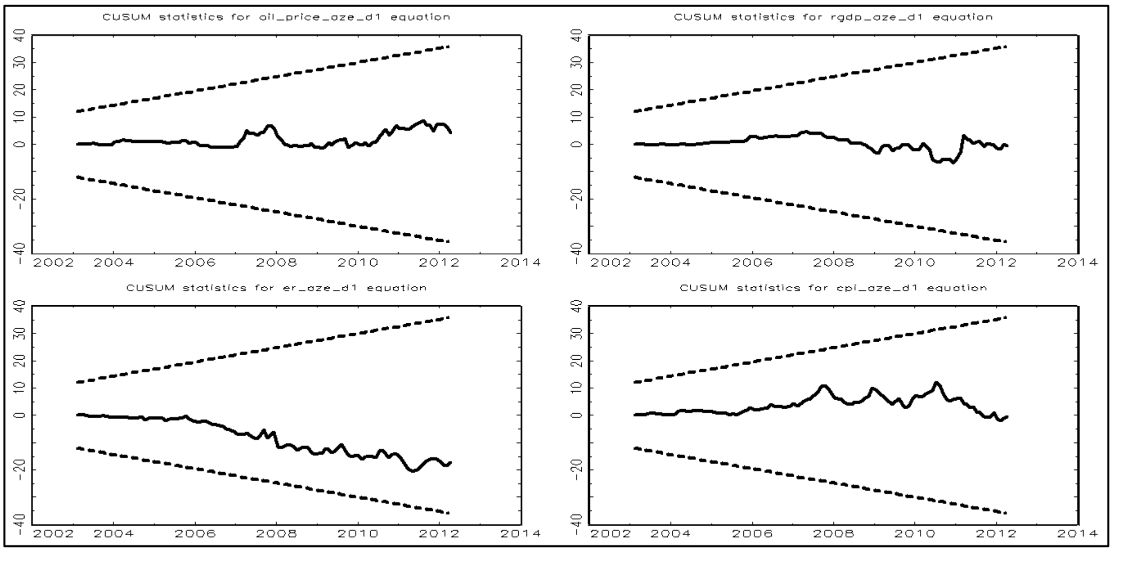

Figure 5.2.1.4: CUSUM statistics for Model 1 with first differences

Source: author's computations.

5.2.2 Structural stability analysis for Georgia

Contrary to the initial specification of Model 1, inverse roots analysis for initial specification of Model 2 with lag order equal to 2 designates that all eigenvalues of the matrix of coefficients appear to be less than |1| and inverse roots fall inside the unit circle which is the evidence of stability of the model (See Figure 5.2.2.1 and Table 5.2.2.1).

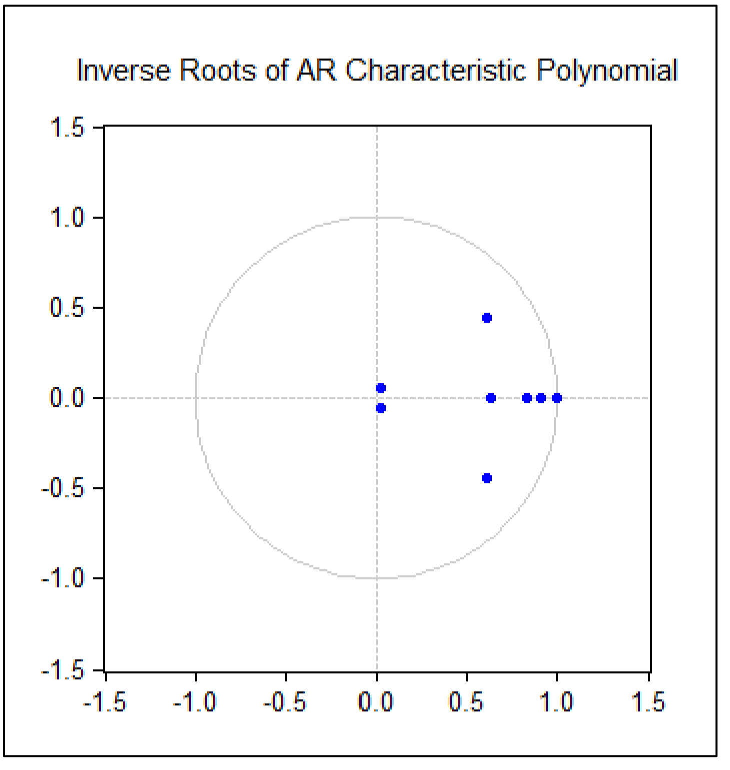

Figure 5.2.2.1: AR roots graph for Model 2

Source: author's computations.

Table 5.2.2.1: AR roots table for Model 2

Root	Modulus
Roots of Characteristic Polynomial Endogenous variables: OIL_PRICE_GEO RGDP_GEO ER_GEO CPI_GEO Exogenous variables: C Lag specification: 1 2	
Root	Modulus
0.998489	0.998489
0.908638	0.908638
0.826178	0.826178
0.608631 - 0.440257i	0.751171
0.608631 + 0.440257i	0.751171
0.632508	0.632508
0.023133 - 0.057001i	0.061517
0.023133 + 0.057001i	0.061517
No root lies outside the unit circle. VAR satisfies the stability condition.	

Source: author's computations.

In the same fashion, cumulative sum of recursive residuals for each series in the CUSUM test are varying within its confidence intervals indicating that the whole sample is stable (See Figure 5.2.2.2).

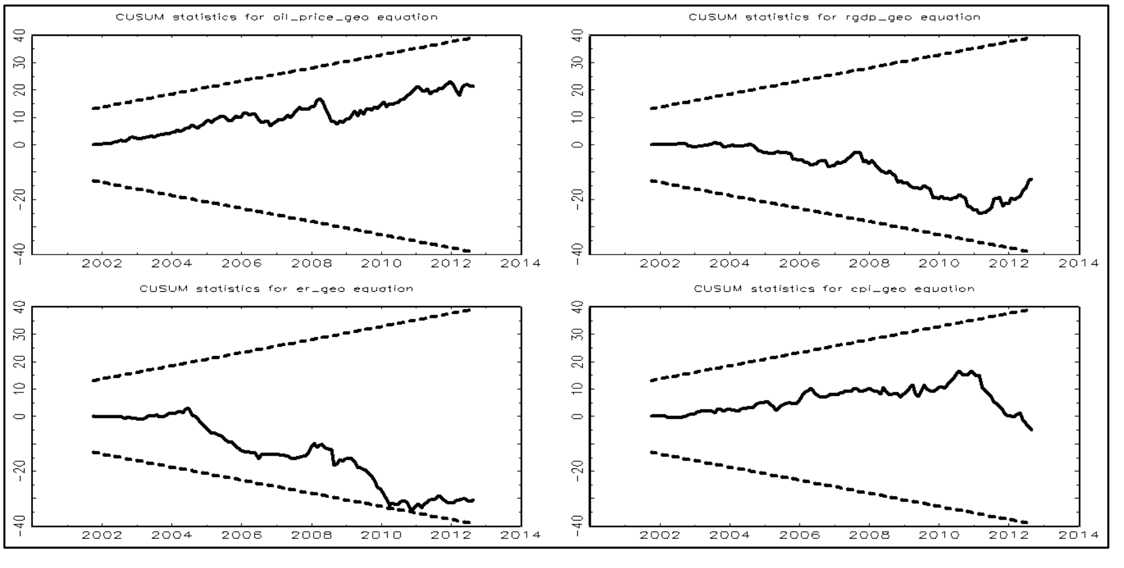

Figure 5.2.2.2: CUSUM statistics for Model 2

Source: author's computations.

To summarize, VAR process is stable for the initial specification of the model for Georgia and it can be estimated further. However, in case with the model for

Azerbaijan, specification was changed by transforming the variables into first differences in order to acquire structural stability and be able to estimate the model.

5.3 Residual analysis

To check whether the lag order of VAR process was chosen correctly or not, autocorrelation in the residuals shall be tested. The basic tests for autocorrelation in the residuals are the following: Portmanteau test for autocorrelation, Breusch-Godfrey LM (Lagrange Multiplier) test for autocorrelation and LMF test (Lagrange Multiplier F-test) for autocorrelation. Portmanteau test for residual autocorrelation is generally used for the VAR processes with no exogenous variables and allows for subset restrictions applied. It tests for the null hypothesis that there is no autocorrelation in the residuals against the alternative hypothesis that at least one autocorrelation is nonzero. Breusch-Godfrey LM and LMF tests for residual autocorrelation are based on the following model:

$$u_t = B_1^* u_{t-1} + \ldots + B_h^* u_{t-h} + \varepsilon_t \quad \textbf{(5.2)}$$

In the same way as Portmanteau test, they test for the null hypothesis of no autocorrelation ($H_0: B_1^* = \ldots = B_h^* = 0$) versus alternative hypothesis that at least one autocorrelation is nonzero ($H_1: B_1^* \neq 0 \; or \; \ldots \; or \; B_h^* \neq 0$). The difference between LM and LMF tests is in the way of computing test statistic. As suggested by Edgerton and Shukur (1999), LM test may be biased in case of small samples. That is why authors developed another LMF statistic which appears to perform better for this case.

Table 5.3.1: The results of the tests for residual autocorrelation in Model 1 with first differences

Test	Test statistic	p-value
Portmanteau test	292.7325	0.0113
Breusch-Godfrey LM test	165.8249	0.0000
LMF test	2.5507	0.0000

Source: author’s computations.

The results of Portmanteau test with the lag order of 16 and LM tests with the lag order of 5 for Model 1 with first differences confirm the presence of autocorrelation strongly rejecting the null hypotheses of no autocorrelation (See Table 5.3.1).

Table 5.3.2: The results of the tests for residual autocorrelation in Model 2

Test	Test statistic	p-value
Portmanteau test	475.8532	0.0000
Breusch-Godfrey LM test	134.7276	0.0001

Source: author’s computations.

Similarly, the results of Portmanteau test with the lag order of 16 and LM test with the lag order of 5 for Model 2 lead to the strong rejection of null hypotheses and indicate that autocorrelation in the residuals exists (See Table 5.3.2). LMF test was not performed as LMF statistic could not be computed due to initial subset restrictions applied to Model 2.

To overcome this fact, the attempts to increase the lag order based on other information criteria and to include dummy variable for the period of crisis in 2008 were made. However, these efforts did not bring any improvements into results of the tests. It was decided to keep the number of lags the same based on Schwarz Information Criterion for simplicity of the estimation.

5.4 Granger causality testing

Granger causality is a statistical concept of causal relationships between the variables of the model based on forecasting properties. According to Lutkepohl (1991), if one variable has a forecasting power on another one, that is, if it contains some information that helps to predict future values of another variable, then it is said to Granger-cause that variable. This concept is highly important for the policymakers as they can use it to study the consequences of decisions made in a particular area. For instance, by studying causality relationships between output and price level, it is possible to identify that it would be more effective to take actions either towards inflation rate or towards output level, or towards both of them. Granger causality testing is intended to identify such kind of relationships among the variables. The null hypothesis for Granger causality test is that there are no causal relationships among the variables. And, accordingly, alternative hypothesis states that causal relationships among the variables exist.

5.4.1 Granger causality testing for Azerbaijan

As a result of Granger causality test for Model 1 with first differences, where the cause variable is *“oil_price_aze_d1”* and the effect variables are macroeconomic indicators of Azerbaijan – *“rgdp_aze_d1”*, *“er_aze_d1”*, and *“cpi_aze_d1”*, the null hypothesis saying that average crude oil price does not Granger-cause real GDP, exchange rate and inflation rate in Azerbaijan is strongly rejected with p-value equal to 0.0004 (See Table 5.4.1.1). This result supports the intuition that average crude oil price level should significantly Granger-cause macroeconomic indicators of Azerbaijan, as Azerbaijan is one of the largest oil producers and oil exporters in the region and its economy is highly dependent on oil industry.

Table 5.4.1.1: Test for Granger causality of Model 1 with first differences (Cause variable: *“oil_price_aze_d1”*, effect variables: *“rgdp_aze_d1”, “er_aze_d1”, “cpi_aze_d1”*)

TEST FOR GRANGER-CAUSALITY:
H0: "oil_price_aze_d1" do not Granger-cause "rgdp_aze_d1, er_aze_d1, cpi_aze_d1"
Test statistic l = 6.2056
pval-F(l; 3, 544) = 0.0004

Source: author’s computations.

Also, the question of interest is whether the macroeconomic indicators of Azerbaijan Granger-cause world average oil price or not. The results of Granger causality test with cause variables as *“rgdp_aze_d1”*, *“er_aze_d1”* and *“cpi_aze_d1”* and effect variable as *“oil_price_aze_d1”* suggest that, actually, macroeconomic indicators of Azerbaijan do not contain any information that may be used in forecasting of average crude oil price. The null hypothesis of the absence of Granger causality relationships between real GDP, exchange rate and inflation rate of Azerbaijan on one side, and average crude oil price on the other side can not be rejected with p-value equal to 0.4892 (See Table 5.4.1.2). And, this fact is logical, because, even if the economy of Azerbaijan is dependent on oil and its macroeconomic indicators vary with changes in oil prices, its oil exports are still not large enough to significantly affect prices on world oil trade market. Significant changes in macroeconomic indicators of Azerbaijan could affect future average crude oil price levels if Azerbaijan was one of the largest oil exporters in the world.

Table 5.4.1.2: Test for Granger causality of Model 1 with first differences (Cause variables: *"rgdp_aze_d1", "er_aze_d1", "cpi_aze_d1",* effect variable: *"oil_price_aze_d1"*)

TEST FOR GRANGER-CAUSALITY:
H0: "rgdp_aze_d1, er_aze_d1, cpi_aze_d1" do not Granger-cause "oil_price_aze_d1"
Test statistic l = 0.8091
pval-F(l; 3, 544) = 0.4892

Source: author's computations.

5.4.2 Granger causality testing for Georgia

Granger causality test for Model 2 which tests whether the *"oil_price_geo"* Granger-causes the *"rgdp_geo"*, *"er_geo"* and *"cpi_geo"* indicates that the macroeconomic indicators of Georgia are significantly Granger-caused by the average crude oil price. The null hypothesis which states that average crude oil price does not Granger-cause real GDP, exchange rate and inflation rate in Georgia is strongly rejected with p-value equal to 0.0001 (See Table 5.4.2.1). This evidence is supported by the intuition that Georgia is an oil importing country. That is why, its energy costs and, further, macroeconomic indicators will depend on oil price level.

Table 5.4.2.1: Test for Granger causality of Model 2 (Cause variable: *"oil_price_geo",* effect variables: *"rgdp_geo", "er_geo", "cpi_geo"*)

TEST FOR GRANGER-CAUSALITY:
H0: "oil_price_geo" do not Granger-cause "rgdp_geo, er_geo, cpi_geo"
Test statistic l = 4.6295
pval-F(l; 6, 528) = 0.0001

Source: author's computations.

The vice versa testing for whether macroeconomic indicators of Georgia Granger-cause average crude oil price is skipped in this paper as it initially assumes that there is no effect of Georgian macroeconomic indicators on average crude oil price and corresponding subset restrictions were implemented into the model.

5.5 Impulse response functions analysis

Granger causality does not build a complete picture of relationships between the variables in VAR process for a researcher. In such kind of estimation, one of the main points of interest is the impulse response functions. They are usually used to investigate the dynamic interactions among the endogenous variables of a VAR process. Based on Koop, Pesaran and Potter (1996), impulse responses are tracking the response of current and future values of every single variable in the model to a one-unit, or, in other words, to a one-standard deviation shock in one of the other variables of the model. That is why, it is crucial to know how each variable in a system responds to the structural shocks in any other variable of the same system to have an idea about the interactions between the variables. Such kind of impulse response analysis is named multiplier analysis.

One standard deviation shocks are applied to the error term of the each equation in the model sequentially and, after, the respond of the whole VAR system to the particular shock are studied. For instance, in this paper, when a structural shock is implemented to the error term u_{1t} in the first equation of oil price level in initial specification of Model 1, which is:

$$\begin{aligned} oil\_price\_aze(t) &= \varphi_1 + \delta_{11} \times oil\_price\_aze(t-1) + \delta_{12} \times rgdp\_aze(t-1) + \delta_{13} \times er\_aze(t-1) + \delta_{14} \times cpi\_aze(t-1) + \theta_{11} \\ &\times oil\_price\_aze(t-2) + \theta_{12} \times rgdp\_aze(t-2) + \theta_{13} \times er\_aze(t-2) + \theta_{14} \times cpi\_aze(t-2) + u_{1t} \end{aligned} \quad \textbf{(5.3)}$$

Real GDP, exchange rate and inflation rate in Azerbaijan are expected to give a reaction to this shock and the way they react is the object of interest.

The same procedure is applied for all equations in Model 1 with first differences and for Model 2.

Moreover, before formulating the impulse responses it is important to build confidence intervals which illustrate the uncertainty of the estimation. Confidence intervals may be computed using various bootstrapping approaches. In this paper, the 95% Standard (Efron) Percentile Confidence Interval was computed for 20 periods for each dataset. Based on Efron and Tibshirani (1993), this approach implies that the model is first estimated using bootstrapped samples in quantities of interest and the bootstrap coefficient is derived. The number of bootstrap replications was selected equal to 1000 to obtain the reliable confidence intervals. After the estimation, the confidence intervals are determined as follows:

$$CI_S = \left[s^*_{\gamma/2}, s^*_{1-\gamma/2}\right] \quad \textbf{(5.4)}$$

Where $s^*_{\gamma/2}$ and $s^*_{1-\gamma/2}$ are $\gamma/2$-th and $1-\gamma/2$-th quantiles, respectively, of the distribution of the bootstrapped coefficient. Confidence intervals are displayed on the plots below as a dotted line.

5.5.1 Impulse response functions analysis for Azerbaijan

The impulse response functions analysis for Azerbaijan (Model 1 with first differences) starts with investigating the responses of macroeconomic indicators on an oil price shock. As noted by Melolinna (2012), there are 2 main sources of an oil price shock: oil demand shock and oil supply shock. The first one is usually accompanied with an increase in oil price and stimulation of economic activity mainly in oil exporting companies. Oil supply shock, on the contrary, usually leads to decrease in oil price which stimulates economic activity mostly in developed oil importing countries. As Azerbaijan is an oil exporting country, the reaction of its macroeconomic indicators on an oil price shock is expected to be positive.

From Figure 5.5.1.1, it is observable that real GDP of Azerbaijan reacts strongly positive to an oil price shock with significantly increasing trend during the first period after the shock. Then the effect slowly decreases with lower level of significance and converges to 0 in the 8^{th} period after the shock. The effect is significant from the end of the first period and till the 4^{th} period after the shock as confidence intervals suggest. As a support to the results, a positive oil price shock for oil exporting country is going to increase its revenues. Increased revenues create favorable conditions for new investments, which, in their turn, provide a positive trend in GDP. Totally opposite happens is the case when oil price suffers a negative shock.

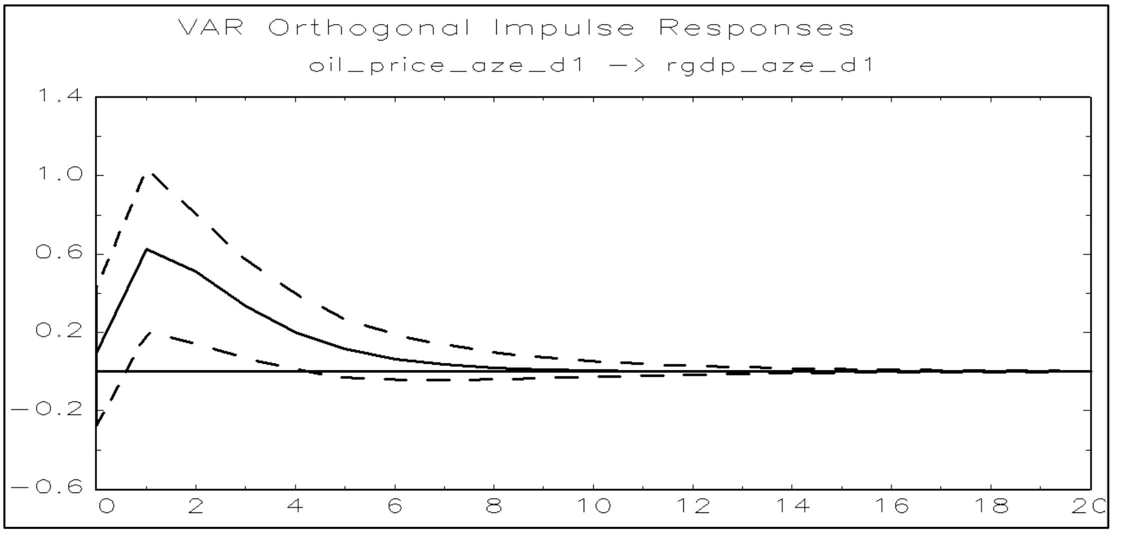

Figure 5.5.1.1: VAR orthogonal impulse responses of *"rgdp_aze_d1"* on a shock in *"oil_price_aze_d1"* in Model 1 with first differences

Source: author's computations.

The impulse response of the exchange rate to an oil price shock in Azerbaijan is also positive. This can be seen from Figure 5.5.1.2. The positive effect is growing up to the first 2 months after the shock where it becomes significant, then it is slowly decreasing with lower level of significance and converges to zero in 13^{th} month after the shock. In this way, these effects are significant only from the 3^{rd} until the 8^{th} period after the shock based on confidence intervals. This fact is true, while, as noticed before, an increase (decrease) in oil price corresponds to a reasonable rise (fall) in revenues and, accordingly, in amount of national currency in circulation for Azerbaijan. It signals about appreciation (depreciation) of Azerbaijani manat. For instance, an increase in exchange rate of manat, i.e. its strengthening compared to US dollar in this particular case, after positive shock in oil price is good for the Azerbaijani economy. Basically, enhancement of the national currency means that a country can accumulate more resources and, in such a way, increase its "value". However, this effect is good only in a short run and not in a long run. Because, in a long run, appreciation of the national currency may slow down economic growth as it encourages import of the foreign goods. This fact is not good for the economy of Azerbaijan, which, even without that, is highly dependent on import of goods.

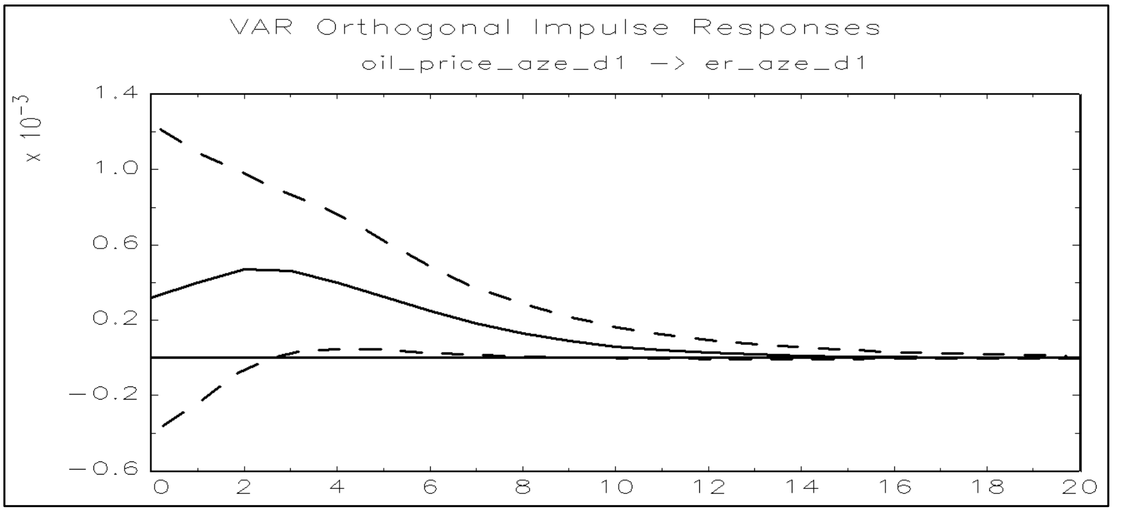

Figure 5.5.1.2: VAR orthogonal impulse responses of *"er_aze_d1"* on a shock in *"oil_price_aze_d1"* in Model 1 with first differences

Source: author's computations.

As it is visible from Figure 5.5.1.3, the reaction of the inflation in Azerbaijan to an oil price shock is positive and significantly rising until the 2nd period after the shock. Starting from the 2nd period, it declines with decreasing level of significance until the 12th period, i.e. one year, after the shock where it converges to zero. According to the confidence intervals, observed effect is significant from the first and until the 7th month after the shock. This evidence also supports the intuition. Generally, if an oil price shock positively affects the macroeconomy in Azerbaijan, as suggested by the response of real GDP and exchange rate, it is expected to positively affect inflation rate, too, as economic growth (decline) is usually followed by a rise (fall) in inflation. Nevertheless, as in case with the exchange rate, such long-term effect in case of positive oil price shock may also have a negative impact on the economy. High level of inflation may decrease domestic demand and bring recession to the economy. That is why inflation rate is one of the main objects of monetary policy in every country.

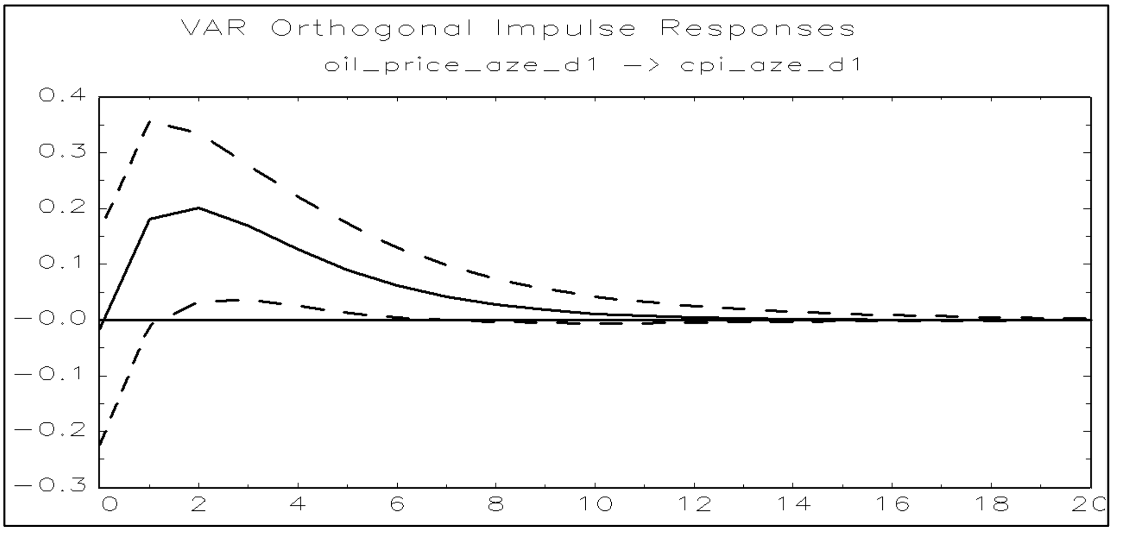

Figure 5.5.1.3: VAR orthogonal impulse responses of *"cpi_aze_d1"* on a shock in *"oil_price_aze_d1"* in Model 1 with first differences

Source: author's computations.

To sum up, an oil price shock has a significant stimulating effect on economic growth in Azerbaijan during the initial periods after the shock and converges to zero later on. This evidence is supported by the results obtained by Ito (2010) on the example of Russian economy.

Further, the paper analyzes the vice versa impulse responses of the oil price on shocks in macroeconomic indicators in Azerbaijan, which were expected to be insignificant, as Azerbaijan falls only into top 30 world's largest oil exporters according to U.S. Energy Information Administration statistics of 2013 and may not have enough power to affect average crude oil price.

Figure 5.5.1.4 demonstrates the impulse responses of average crude oil price on a shock in Azerbaijani real GDP indicator. Oil price reacts positively on a shock in real GDP with increasing trend for the first month after the shock and converging to zero later. However, this effect is insignificant for the whole period after the shock.

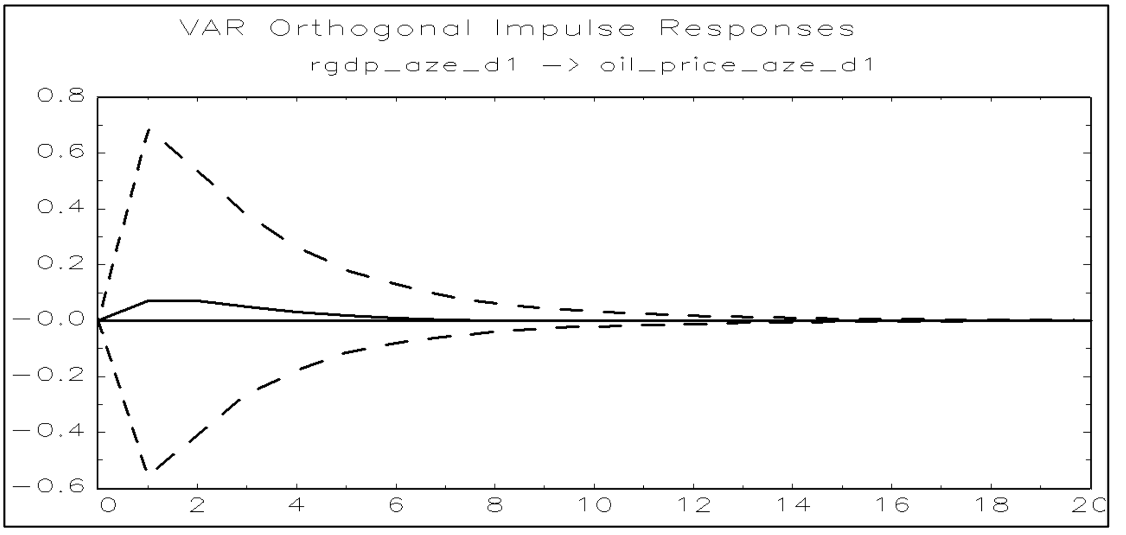

Figure 5.5.1.4: VAR orthogonal impulse responses of *"oil_price_aze_d1"* on a shock in *"rgdp_aze_d1"* in Model 1 with first differences

Source: author's computations.

Inversely, the impulse response of average crude oil price on a shock in exchange rate of Azerbaijani manat is negative decreasing throughout the first month after the shock and converging to zero later on. But, like in case with a real GDP shock, the effect is insignificant for the whole period after the shock as demonstrated on Figure 5.5.1.5.

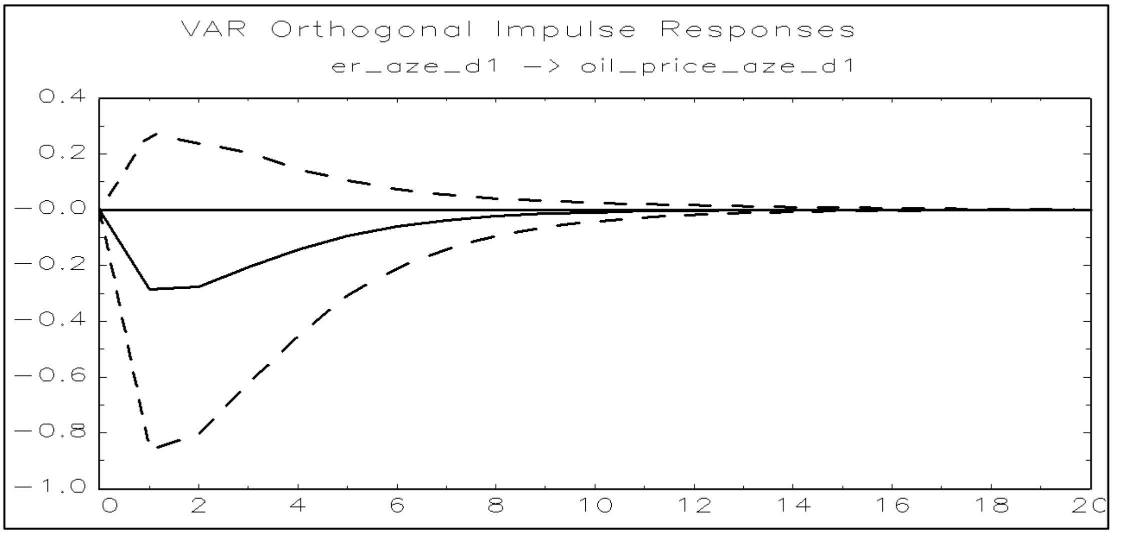

Figure 5.5.1.5: VAR orthogonal impulse responses of *"oil_price_aze_d1"* on a shock in *"er_aze_d1"* in Model 1 with first differences

Source: author's computations.

The reaction of average crude oil price on a shock in CPI of Azerbaijan is positive, but much higher than the reaction on a shock in Azerbaijani GDP. As it is visible from Figure 5.5.1.6, oil price response is positively increasing for the first period after the shock and continues converging to zero further. As for all the previous Azerbaijani macroeconomic indicators, the effect of a shock in the inflation on the oil price is insignificant for all 20 periods after shock.

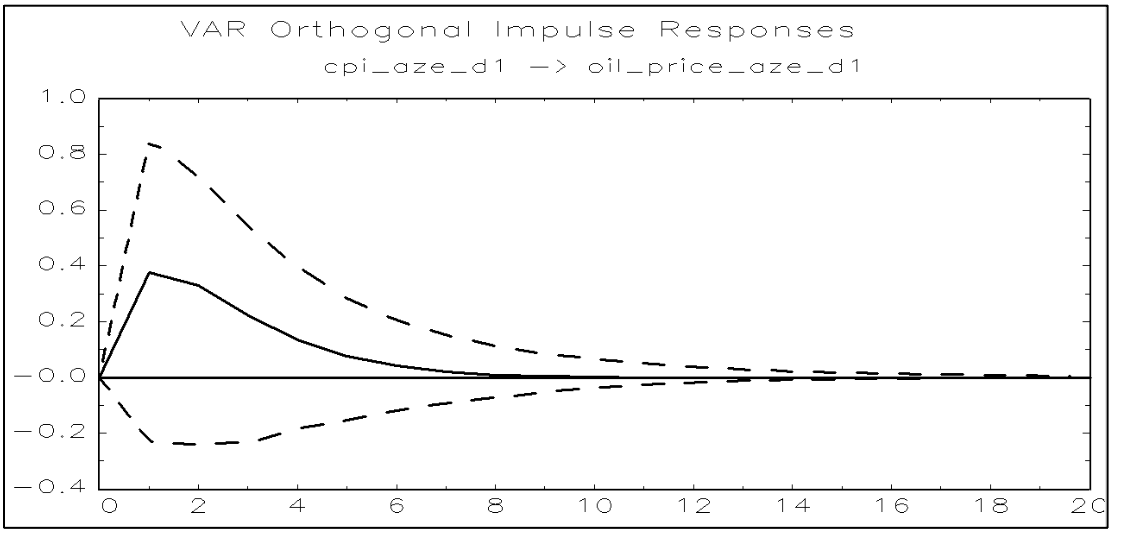

Figure 5.5.1.6: VAR orthogonal impulse responses of *"oil_price_aze_d1"* on a shock in *"cpi_aze_d1"* in Model 1 with first differences

Source: author's computations.

To summarize, macroeconomic variables in Model 1 with first differences did not appear to significantly affect the average crude oil prices as expected. The positive responses of the oil price on shocks in real GDP and CPI in Azerbaijan could be reasonable if significant as GDP and inflation are the main indicators of economic growth and are expected to affect the oil price positively. However, the negative effects of an exchange rate shock on the oil price are abnormal. Exchange rate is another important indicator of economic growth and is expected to positively affect the oil price. Nevertheless, the results of impulse response functions analysis showed that all the responses of the oil price are insignificant as the zero line falls inside the confidence intervals. This evidence confirms the basic intuition and the results of Granger causality testing.

5.5.2 Impulse response functions analysis for Georgia

The impulse response functions analysis for Georgia (Model 2) was performed only regarding the responses of Georgian macroeconomic indicators on a shock in average crude oil price and not vice versa, relying on the initial assumption of the paper, which supposes that macroeconomic indicators of Georgia do not have an impact on average crude oil price. As Georgia imports almost all of oil and gas products for its needs, the reaction of its real GDP and exchange rate on an oil price shock is expected to be negative and, at the same time, the reaction of inflation rate in Georgia is expected to be positive.

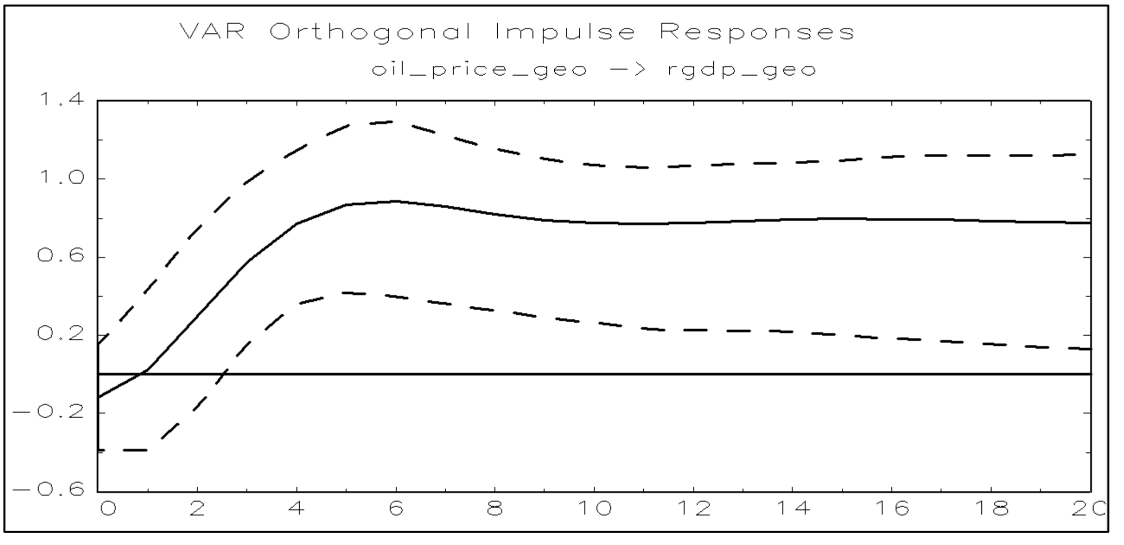

Figure 5.5.2.1: VAR orthogonal impulse responses of *"rgdp_geo"* on a shock in *"oil_price_geo"* in Model 2

Source: author's computations.

However, as it is observable from Figures 5.5.2.1 and Figure 5.5.2.2, the impact of an oil price shock on Georgian real GDP, exchange rate is actually positive and highly significant. Figure 5.15 indicates that the positive impulse response of Georgian real GDP on a shock in oil price becomes significant 2 months after the shock, rises until the 6th month after the shock and remains constant later on. In the same fashion, Figure 5.16 demonstrates that the impact of an oil price shock on the exchange rate of Georgian lari is positive and significant straight after the shock and further increases throughout the whole period after the shock.

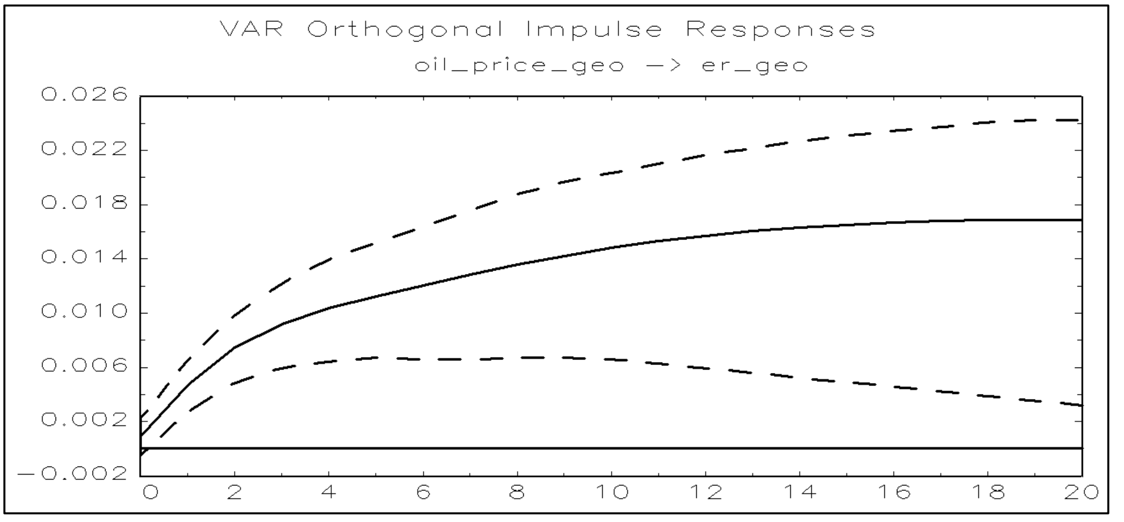

Figure 5.5.2.2: VAR orthogonal impulse responses of *"er_geo"* on a shock in *"oil_price_geo"* in Model 2

Source: author's computations.

The effect of an oil price shock on the Georgian CPI is positive as expected. However, Figure 5.5.2.3 demonstrates that this effect is too strong and significant during the whole period after the shock.

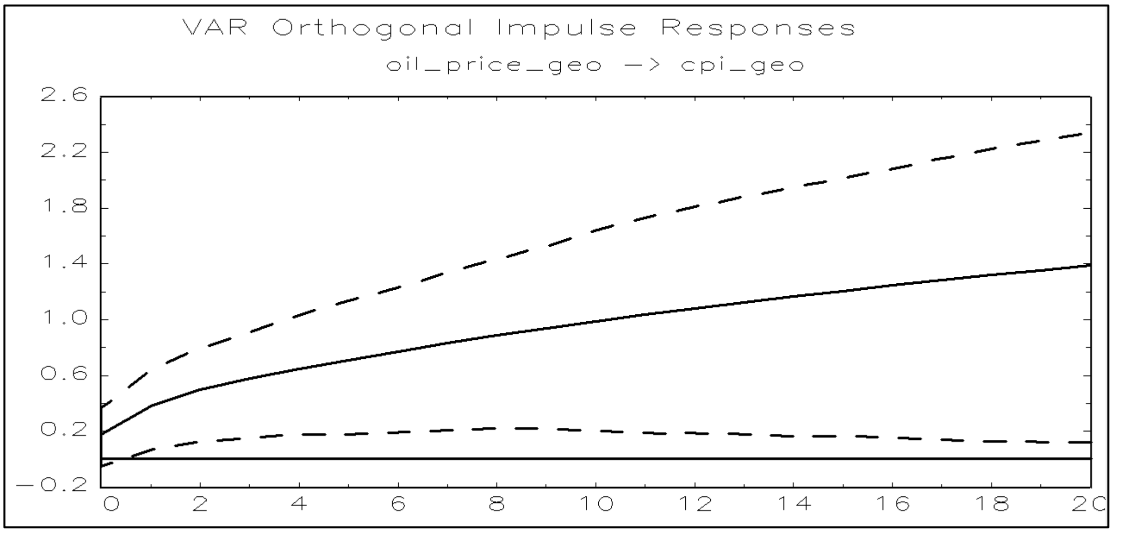

Figure 5.5.2.3: VAR orthogonal impulse responses of *"cpi_geo"* on a shock in *"oil_price_geo"* in Model 2

Source: author's computations.

To summarize the impulse response functions in Model 2, a shock in the oil price mostly has unexpected positive and significant effects on the macroeconomy of Georgia, which appear to be abnormal.

These abnormal results may be consequences of wrong specification in the model. As an attempt to correct Model 2 specification, following techniques were employed: logarithmic transformation of the variables, first differencing of the variables, introduction of trend shift dummy for the period of sharp oil price drop between July and December 2008, introduction of trend component of Hodrick-Prescott (HP) filter[13] for oil price. The estimation results after implementing logarithmic transformation, first differences and trend shift dummy for the crisis period in 2008 did not change significantly (See Appendix A).

An improvement in the results was obtained after applying HP filter to the variable *"oil_price_geo"* in Model 2 in order to derive long-run trend component of this series. Parameter λ, which reduces variability in trend component, was chosen equal to 1600 in order to obtain smooth trend. The model was re-estimated using trend component of oil price (*"oil_price_geo_hptrend"*) instead of its complete series (*"oil_price_geo"*). The lag order in new specification is equal to 5 based on Schwarz Criterion and the model is denoted as Model 2 with HP filter. The results of impulse response functions in re-estimated model are presented below.

The impulse response of real GDP in Georgia on an oil price shock in Model 2 with HP filter is demonstrated on Figure 5.5.2.4. From the figure, it is observable that Georgian real GDP reacts positively for the first 5 months after the shock, then, the effect becomes negative until the 10th month after the shock and, then, again positive with the trend converging to zero. However, statistical significance of the effect is observed only starting from 1 year and until 20th month after the shock which means that oil price has significant effect on real GDP in long run.

[13] A widely used empirical technique which separates cyclical and growth components of economic time series. For the details see Ahumada and Garegnani (1999).

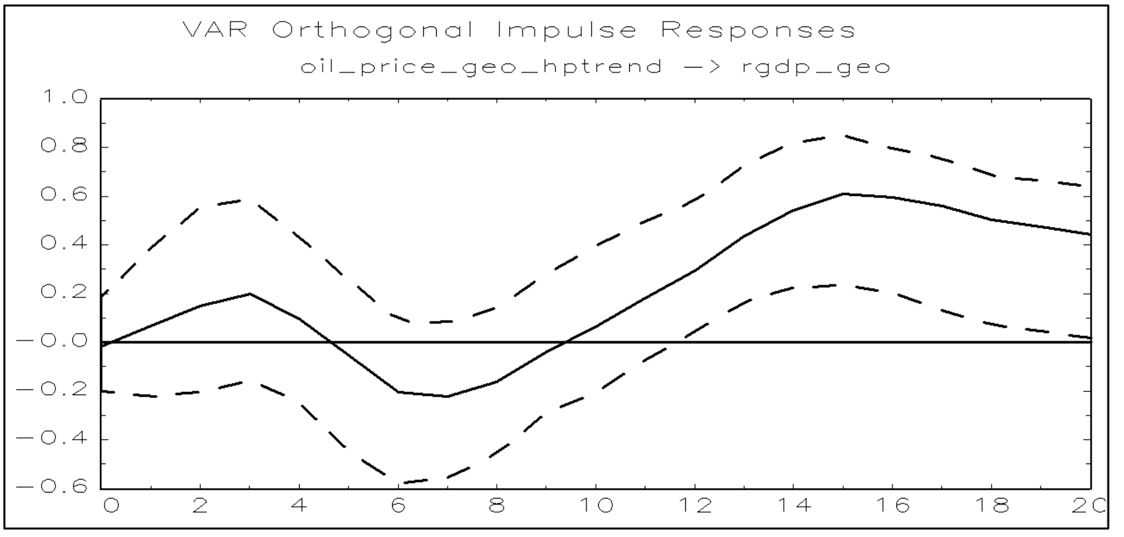

Figure 5.5.2.4: VAR orthogonal impulse responses of *"rgdp_geo"* on a shock in *"oil_price_geo_hptrend"* in Model 2 with HP filter

Source: author's computations.

Based on Figure 5.5.2.5, the impact of an oil price shock on the exchange rate of Georgian lari is now negative for the first 15 periods after the shock and switches to positive further. However, significant effect is observed only from the first and until the 9th period after the shock. Significant and negative response of exchange rate in Georgia for the first several periods after an oil price shock is reasonable as an increase (decrease) in energy costs is going to result in a decrease (increase) in money supply in the economy which leads to currency depreciation (appreciation). Currency depreciation can be good for the country, but only in the short term, because it stimulates domestic production as foreign goods become more expensive.

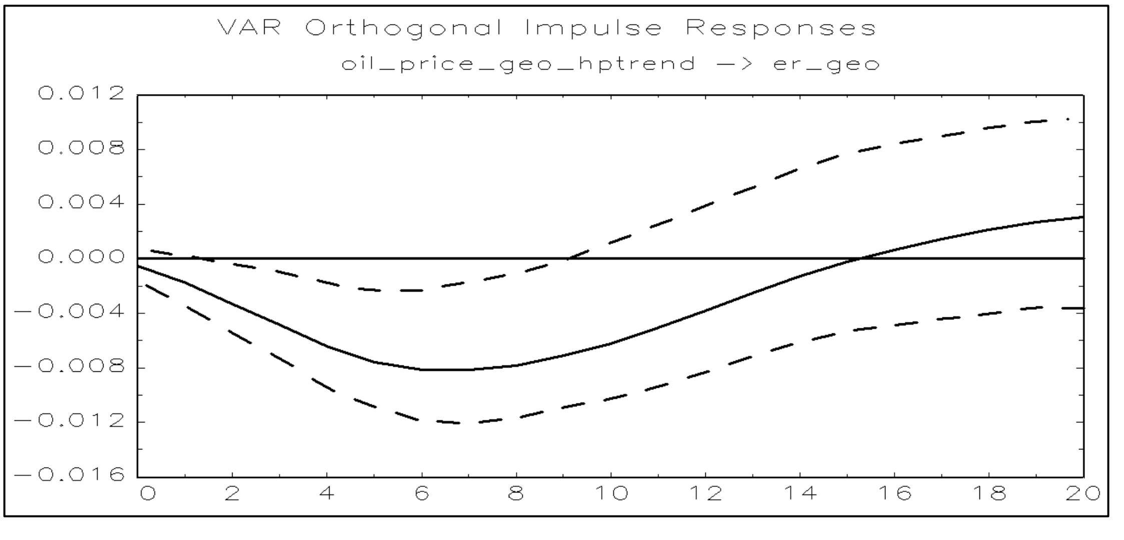

Figure 5.5.2.5: VAR orthogonal impulse responses of *"er_geo"* on a shock in *"oil_price_geo_hptrend"* in Model 2 with HP filter

Source: author's computations.

As it is visible from Figure 5.5.2.6, the impulse response of CPI in Georgia on a shock in oil price is negative for the first 11 periods after the shock and becomes positive after. The response appears to be significant and positive starting only from 16th period after the shock indicating that the effect of oil price on inflation is long run as well as in case of real GDP. It is important to notice that, in this sense, an increase in inflation will not be good for Georgian economy, as in case with Azerbaijan, as it is caused not by growth of production itself, but by increase in energy costs of production.

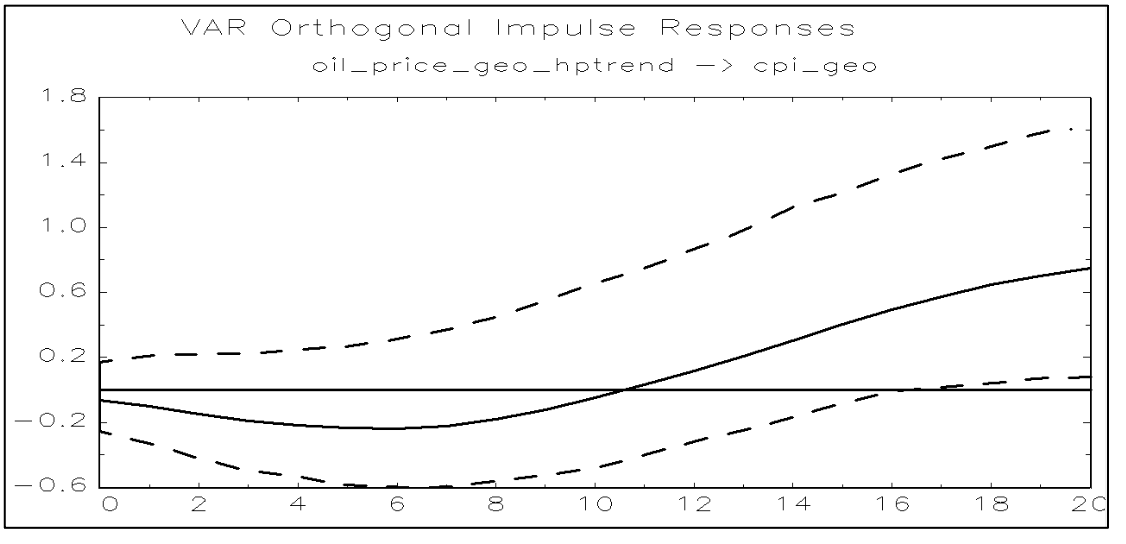

Figure 5.5.2.6: VAR orthogonal impulse responses of *"cpi_geo"* on a shock in *"oil_price_geo_hptrend"* in Model 2 with HP filter

Source: author's computations.

It is obvious that implementation of trend component of HP filter into Model 2 has improved the results obtained with initial specification of the model. However, the response of real GDP in Georgia on an oil price shock still appears to be positive. This result is supported by the results of Ito (2010) and Du, He and Wei (2010) who studied similar relationships in Belarus and China, respectively. The intuition behind this unusual evidence may be the point that Georgia has very specific trade relations with its oil exporting neighbors, such as Azerbaijan and, in particular, Russia, which is one of the world's largest exporters and has power to affect the oil prices, and is highly dependent on their economies. Inexpensive imports of oil and gas from Azerbaijan give a significant support to the economy of Georgia. On the other hand, as mentioned before, Georgia possesses a very important geopolitical location being a transit country for Caspian Energy Corridor. Large portion of Azerbaijani oil and gas exports to Europe and, also, Russian oil and gas exports to Armenia pass through the territory of Georgia. Therefore, Georgia gains significant revenues in the form of transitional costs on the contractual basis, which may stimulate the economic growth. These facts shed some light on how Georgian real GDP can benefit (lose) from an oil price increase (decrease).

5.6 Forecast error variance decomposition analysis

Forecast error variance decomposition is another tool of interpreting VAR models. In variance decompositions variation of each endogenous variable is transformed into a component shock to the whole VAR system. Therefore, variance decomposition appears to contain important information about the effects of every single innovation on the variables in VAR process. It indicates which shocks explain the largest portion of variation of all variables in VAR model, or, in other words, which shocks drive the dynamics of all variables in VAR process.

According to Lutkepohl (1991), the error in forecasting for each horizon h looks as follows:

$$y_{k,T+h} - y_{k,T+h|T} \quad \textbf{(5.5)}$$

The variance of the forecast error is interpreted by the following formula:

$$\sigma_k^2(h) = \sum_{n=0}^{h-1} (\rho_{k1,n}^2 + \cdots + \rho_{kK,n}^2) = \sum_{j=1}^{K} (\rho_{kj,0}^2 + \cdots + \rho_{kj,h-1}^2) \quad \textbf{(5.6)}$$

where the term $(\rho_{kj,0}^2 + \cdots + \rho_{kj,h-1}^2)$ stands for the contribution of variable j to the variance of forecast error of the variable k for the horizon h. Finally, to obtain same contribution on a percentage basis, it is necessary to divide this term by the forecast error variance $\sigma_k^2(h)$:

$$\omega_{kj}(h) = (\rho_{kj,0}^2 + \cdots + \rho_{kj,h-1}^2) / \sigma_k^2(h) \quad \textbf{(5.7)}$$

5.6.1 Forecast error variance decomposition analysis for Azerbaijan

Figure 5.6.1.1 demonstrates the variance decomposition for the forecast errors of variable *"oil_price_aze_d1"* in Model 1 with first differences. From the figure it can be noticed that variation in oil price is totally explained by its previous lags for the first period with a very low decrease afterwards. For the chosen horizon of 20 periods still substantial 97% of variation in *"oil_price_aze_d1"* is explained by its own lags, *"er_aze_d1"* and *"cpi_aze_d1"* explain only 1% of the variation each and no variation is explained by *"rgdp_aze_d1"*.

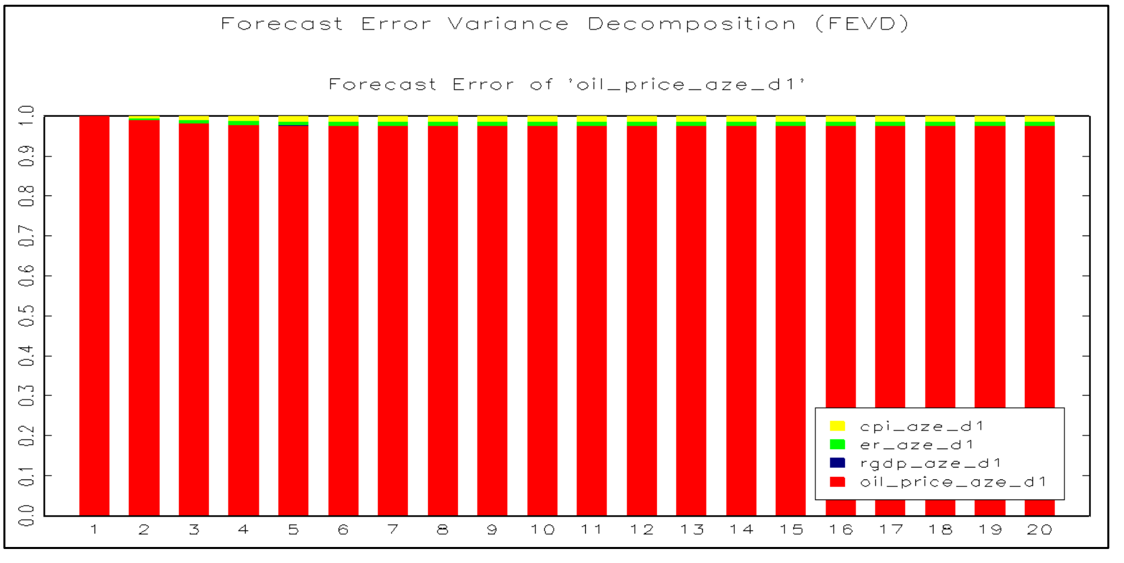

Figure 5.6.1.1: Forecast error variance decomposition of *"oil_price_aze_d1"* in Model 1 with first differences

Source: author's computations.

Forecast error variance decomposition of Azerbaijani real GDP is demonstrated on Figure 5.6.1.2. The variation of *"rgdp_aze_d1"* is absolutely explained by its own lags only in the first period with a slight increase of portion explained by *"oil_price_aze_d1"* after. The portion explained by *"er_aze_d1"* and *"cpi_aze_d1"* is very low during all of the periods. In the horizon of 20 periods 89% of the variation in *"rgdp_aze_d1"* is occupied by itself, 10% is occupied by *"oil_price_aze_d1"* and only 2% is occupied by *"er_aze_d1"* and *"cpi_aze_d1"* – 1% each.

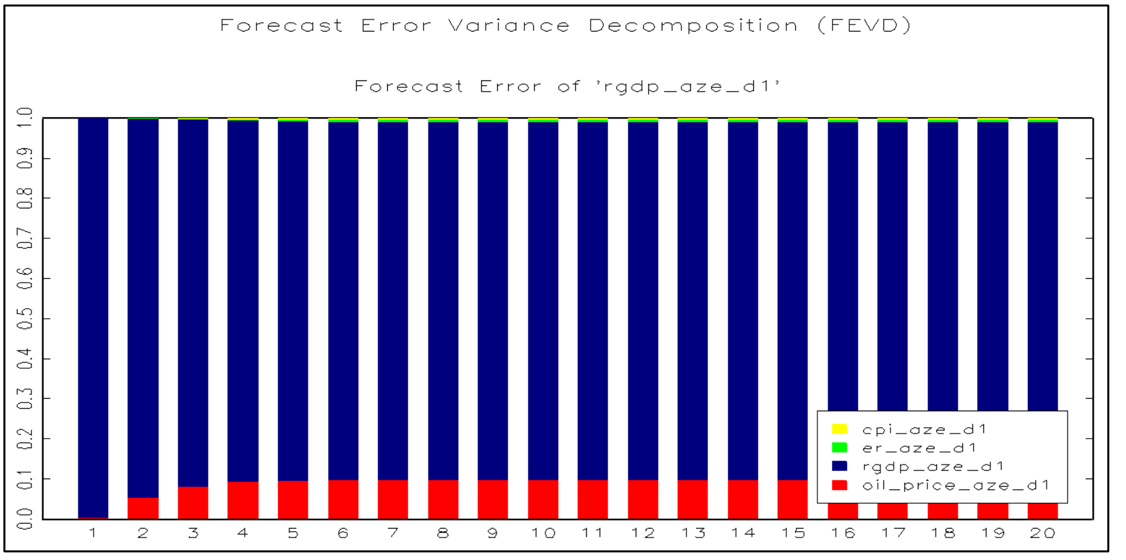

Figure 5.6.1.2: Forecast error variance decomposition of *"rgdp_aze_d1"* in Model 1 with first differences

Source: author's computations.

Variance decomposition of the forecast errors of exchange rate in Azerbaijan, which is reflected on Figure 5.6.1.3, indicates that, as well as in case with real GDP, variation in *"er_aze_d1"* is almost totally explained by its previous values in the first period with increasing influence of *"oil_price_aze_d1"* and *"cpi_aze_d1"* further. The influence of *"rgdp_aze_d1"* is very small throughout all periods. For the 20-period horizon 84% of the variation in *"er_aze_d1"* is interpreted by itself, 7% is interpreted by *"oil_price_aze_d1"*, another 7% is interpreted by *"cpi_aze_d1"* and only 2% is interpreted by *"rgdp_aze_d1"*.

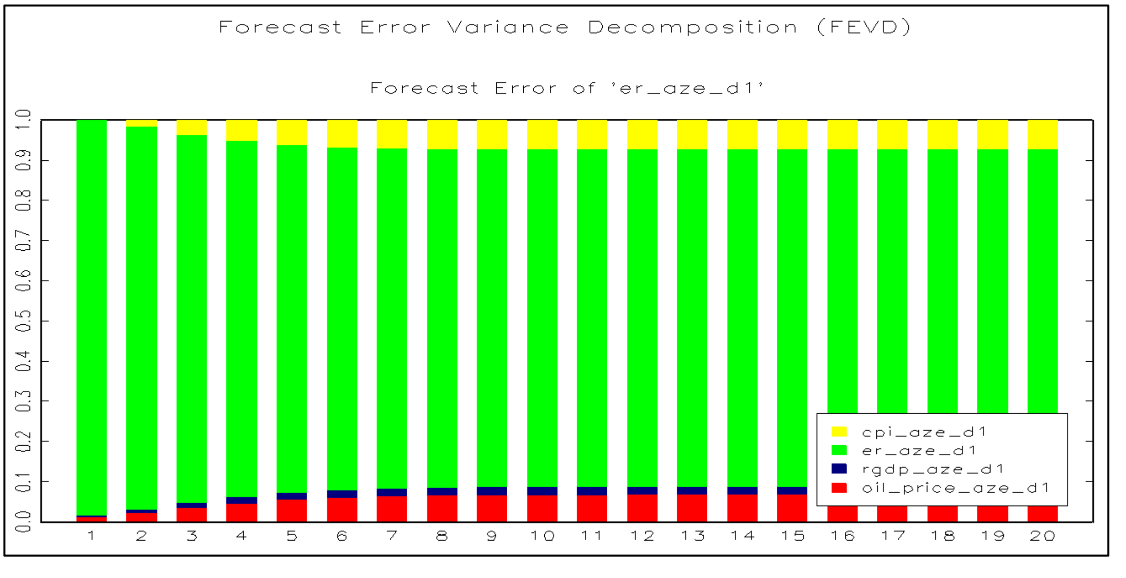

Figure 5.6.1.3: Forecast error variance decomposition of *"er_aze_d1"* in Model 1 with first differences

Source: author's computations.

As it is showed on Figure 5.6.1.4, forecast error variance decomposition of the CPI in Azerbaijan indicates that its variation is also almost totally occupied by itself for the first period. The impact of *"oil_price_aze_d1"* in similar manner is gradually increasing starting from the second period. Variables *"rgdp_aze_d1"* and *"er_aze_d1"* do not significantly explain any variation in *"cpi_aze_d1"*. In the 20-period horizon *"cpi_aze_d1"* accounts for 88% of its variation, *"oil_price_aze_d1"* accounts for 11% of the variation in *"cpi_aze_d1"*, *"rgdp_aze_d1"* accounts for only 1% of the variation in *"cpi_aze_d1"* and *"er_aze_d1"* does not account for any variation in *"cpi_aze_d1"* at all.

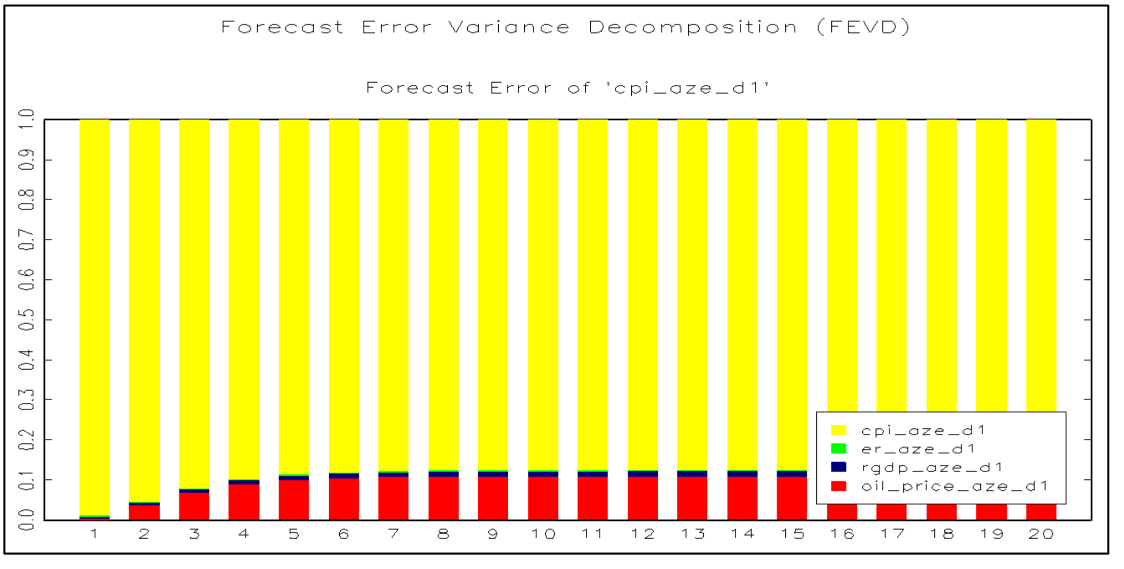

Figure 5.6.1.4: Forecast error variance decomposition of *"cpi_aze_d1"* in Model 1 with first differences

Source: author's computations.

To summarize, average crude oil price appears to explain a small portion of variation in each of the variables. The dynamics of each variable in Model 1 with first differences is mainly driven by its own previous values.

5.6.2 Forecast error variance decomposition analysis for Georgia

As Model 2 assumes that macroeconomic indicators of Georgia do not affect average crude oil price and appropriate subset restrictions were applied in the very beginning, variance decomposition of the forecast errors of *"oil_price_geo_hptrend"* is not analyzed as the variation in oil price is going to be totally explained by its previous values throughout the whole forecast horizon.

Figure 5.6.2.1 demonstrates forecast error variance decomposition of real GDP in Georgia. Variation in *"rgdp_geo"* is completely illustrated by itself in the first period. The effect of *"oil_price_geo_hptrend"* starts to significantly increase from the 3rd period. The impact of *"cpi_geo"* is very low and slightly increasing from the second period. Similarly, *"er_geo"* has very low impact increasing after 4th period and slightly decreasing later on. For the chosen horizon of 20 periods, 65% of the variation in *"rgdp_geo"* is described by its previous values, 28% is described by *"oil_price_geo_hptrend"* and 6% is described by *"cpi_geo"* and *"er_geo"* – 3% each.

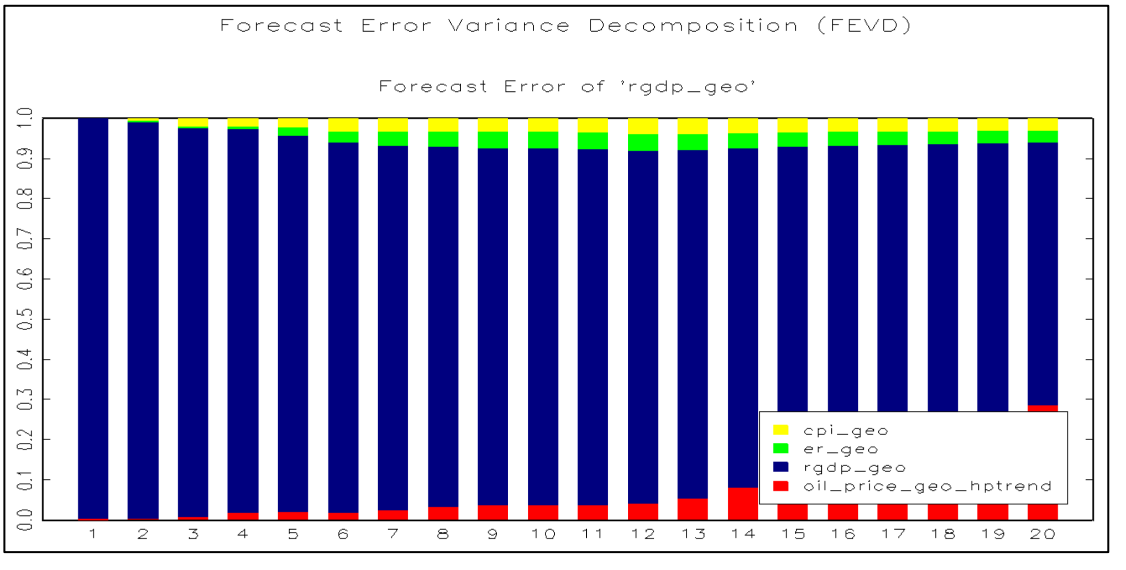

Figure 5.6.2.1: Forecast error variance decomposition of *"rgdp_geo"* in Model 2 with HP filter

Source: author's computations.

As it is showed on Figure 5.6.2.2, forecast error variance decomposition of exchange rate in Georgia indicates that it is mostly explained by its previous values in the first period with significantly increasing effect of *"oil_price_geo_hptrend"* until 11th period and slightly decreasing after. The impact of *"rgdp_geo"* did not appear to be significant over the whole horizon, except the first period where it has some low effect. The small effect of *"cpi_geo"* is even slightly decreasing further. In the 20-period horizon 69% of the variation in *"er_geo"* is defined by itself, 29% is defined by *“oil_price_geo_hptrend”*, and variables *“rgdp_geo”* and *“cpi_geo”* define only 1% of the variation each.

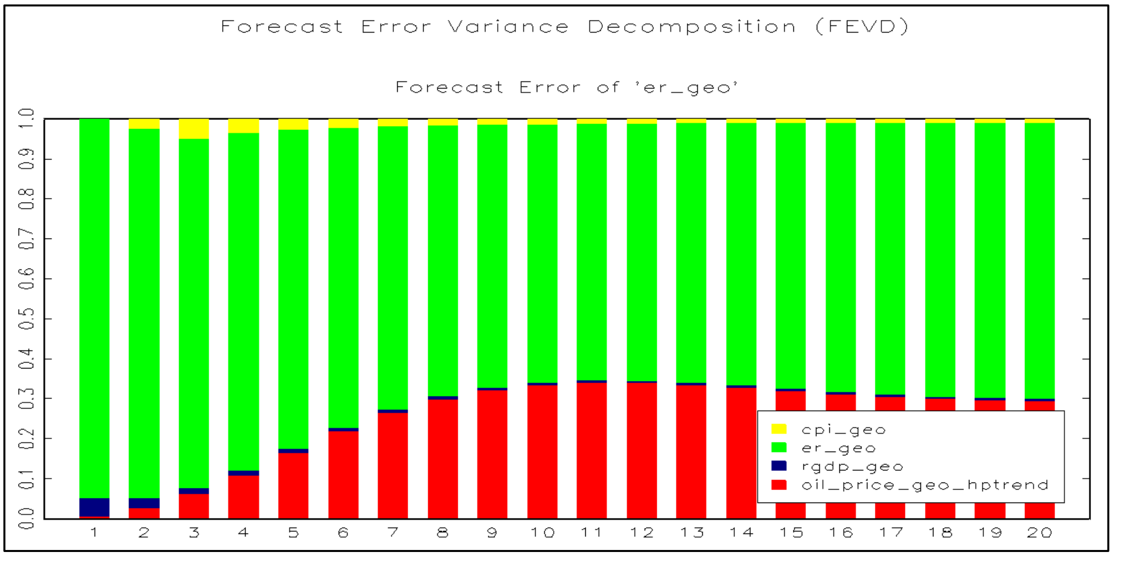

Figure 5.6.2.2: Forecast error variance decomposition of *“er_geo”* in Model 2 with HP filter

Source: author’s computations.

Variance decomposition of the forecast errors of inflation rate in Georgia is demonstrated on Figure 5.6.2.3. Variation in *“cpi_geo”* is mostly described by its own lags throughout the whole horizon. The impact of *“oil_price_geo_hptrend”* starts from the second period and slightly increases further. The portion of variation explained by *“rgdp_geo”* and *“er_geo”* appears to be very low. The effect of *“rgdp_geo”* is slightly decreasing starting from the first period and, oppositely, the effect of *“er_geo”* is slowly increasing starting from 10th period. For the 20-period horizon 80% of the variation in *“cpi_geo”* is occupied by its previous values, 11% is occupied by *“oil_price_geo_hptrend”*, 8% is occupied by *“er_geo”* and only 1% is occupied by *“rgdp_geo”*.

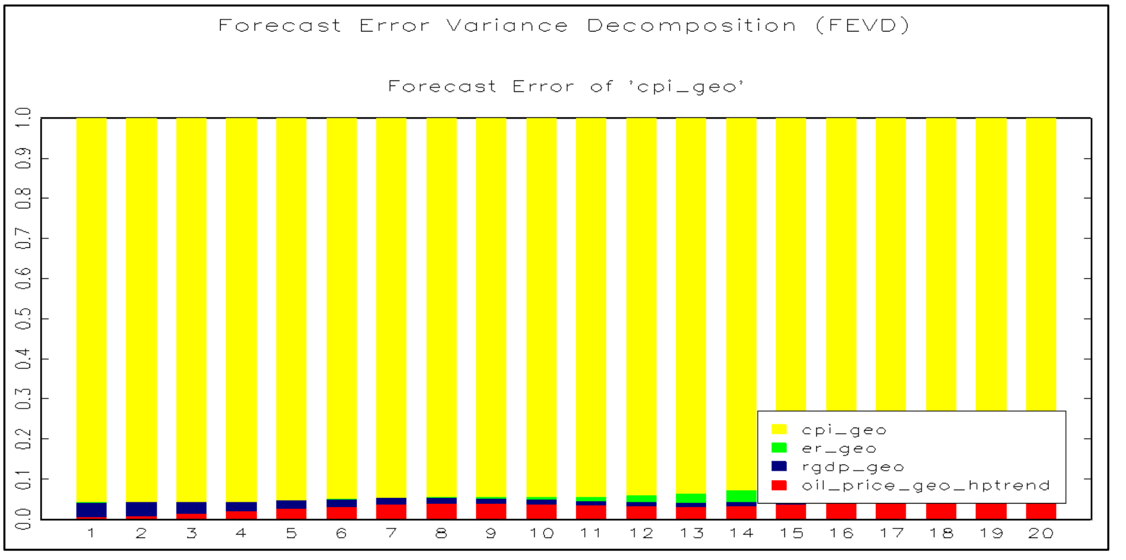

Figure 5.6.2.3: Forecast error variance decomposition of *"cpi_geo"* in Model 2 with HP filter

Source: author's computations.

As in case with Azerbaijan, oil price also accounts for some part of the variation in each macroeconomic indicator of Georgia. However, the main drivers of dynamics in all of the macroeconomic variables in Model 2 with HP trend are their own lags.

6 Conclusion

Recent empirical researches suggest that changes in oil price level may have a significant impact on macroeconomic indicators. This paper investigated the effects of oil price changes on real GDP, exchange rate and inflation rate in Azerbaijan and Georgia using separate multivariate vector autoregressive model for each country with different specifications. It was decided to employ VAR modeling as it is the leading empirical approach in existing literature. The whole estimation was performed based on monthly observations for the period between January 2001 and November 2012. VAR analysis included unit root tests, stability tests, tests for autocorrelation in residuals, Granger causality tests, examination of impulse response functions and variance decomposition. Granger causality testing for the causal effects of Georgian macroeconomy on oil price, the impulse responses of oil price on shocks in each macroeconomic variable of Georgia and the variance decomposition of forecast errors of oil price in the model for Georgia were not performed, relying on the initial assumption and the appropriate block restrictions of the paper that Georgian macroeconomic indicators do not have any effects on average crude oil price. The remaining results of the estimation are summarized below.

First, the results of Granger causality test showed that oil price appears to Granger-cause all macroeconomic indicators in both models. The vice versa testing of whether Azerbaijani macroeconomic indicators Granger-cause average crude oil price or not indicates that, actually, they do not. It means that macroeconomic time series of Azerbaijan do not contain any information that may be used to predict future prices of oil. This fact reflects the reality, because amounts of oil exports from Azerbaijan are still not large enough and, correspondingly, do not have enough power to affect oil pricing on world oil market.

Second, the results of impulse response functions analysis for Azerbaijan have confirmed the results of Granger causality tests revealing that its macroeconomic indicators fail to affect average crude oil price as all the impulse responses of oil price on shocks in each macroeconomic variable appeared to be insignificant. On the contrary, the impulse responses of all 3 macroeconomic indicators on a shock in oil price were positive and significant indicating that oil price level positively affects the macroeconomy of Azerbaijan as expected. The impulse responses of exchange rate and CPI in Georgia were observed to be negative and positive, respectively, as expected. However, the effect of an oil price shock on Georgian real GDP is abnormally positive even though the intuition suggests that an increase in oil price would increase production costs and, hence, lower the GDP. This evidence was supported by the notion of high dependence and specific trade relations of Georgia with its oil producing neighbors, Azerbaijan and Russia, where oil price and macroeconomy are usually positively correlated. Economy of Georgia is highly supported by inexpensive oil and gas imports from Azerbaijan. Moreover, the fact can be addressed to the very important geopolitical location of Georgia which benefits from being a transit country for oil and gas exports to Europe. Generally, the responses of macroeconomic indicators on an oil price shock appeared to be instantaneous in Azerbaijan and belated in Georgia. However, strength of the effects can not be compared between 2 models as each of them has different specification.

Third, forecast error variance decomposition analysis of macroeconomic indicators in both models indicates that average crude oil price explains some part of the variation in each macroeconomic variable. However, the main drivers of dynamics in variation of these variables are the variables themselves, i.e. their previous values. Variance decomposition of the forecast errors of oil price in the model for Azerbaijan also indicates that its macroeconomic indicators do not affect oil price levels as 97% of the variation in oil price is explained by its own values.

Based on the results of estimation demonstrated above, the decisions regarding rejecting or not rejecting hypotheses stated in the beginning of the paper were made. Hypothesis 1, which states that oil price has positive effect on GDP in Azerbaijan, and opposite in Georgia, is rejected as the impulse response of Georgian real GDP on an oil price shock appeared to be also positive. Hypothesis 2, which states that oil price has positive effect on exchange rate in Azerbaijan, and opposite in Georgia, can not be rejected as it is confirmed by the results of impulse response functions analysis. Hypothesis 3, which states that oil price has positive effect on inflation rate in both countries, can not be rejected as it is also verified by the results of impulse response functions analysis. Finally, Hypothesis 4, which states that GDP, exchange rate and inflation rate in Azerbaijan have no effects on oil price, can not be rejected as the results of Granger causality testing, impulse response functions analysis and forecast error variance decomposition totally confirm the intuition.

The analysis in this paper can be further extended in 2 main directions. First, different variables can be used for measuring oil price and macroeconomic activity. For instance, by including interest rate variable into the model it is possible to estimate additional consequences of an oil price shock to an economy and analyze possible monetary policy responses. Instead of oil price levels, it would be reasonable to measure its volatility as standard deviation of changes in oil price, or study the effects of positive and negative oil price shock separately to see which of them is more significant. GDP variable in the model can be substituted by industrial production or employment as alternative measurement of economic activity. Moreover, the effects of an oil price shock on financial markets are of interest and can be analyzed by including stock price variable into the model. Second, the paper can be extended by in-depth analysis of positive reaction of Georgian macroeconomic indicators on a shock in oil price. A detailed analysis of Georgian economy could bring some justified reasons to the abnormal fact it benefits from an oil price increase and loses from an oil price decrease. Also, a multivariate VAR model can be employed in order to study the way how the economy of Georgia is affected by the economies of Azerbaijan and Russia using main macroeconomic indicators.

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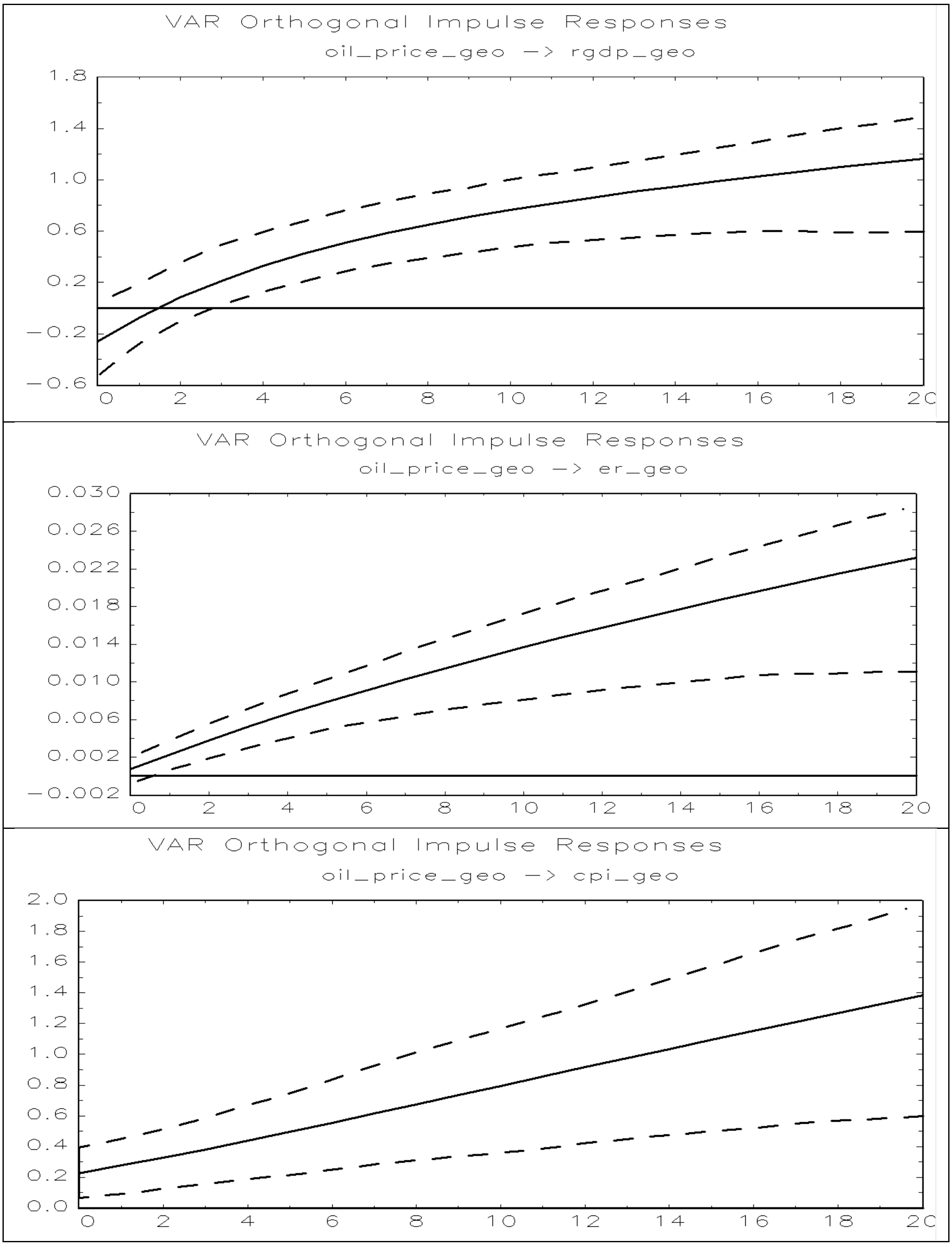
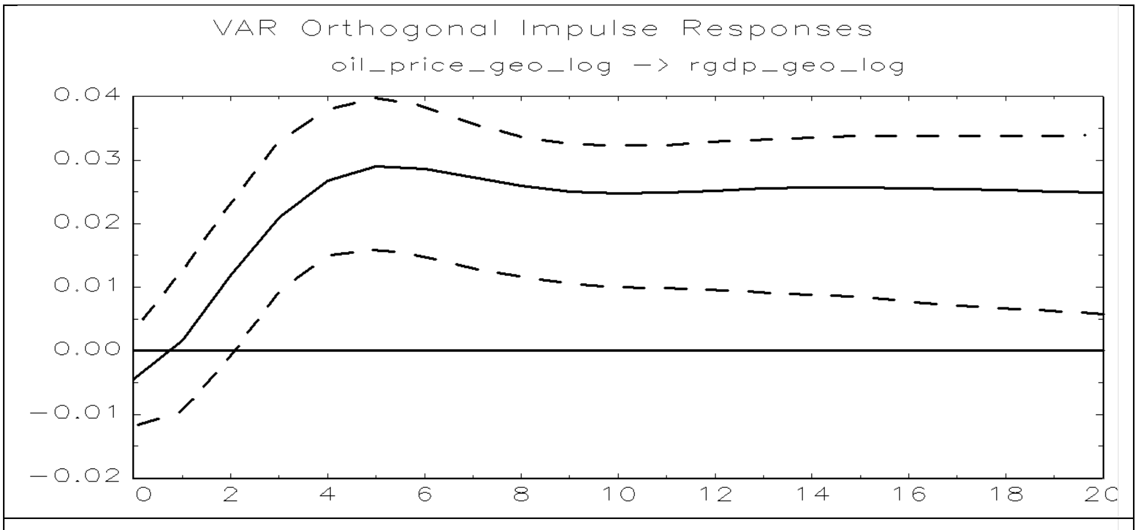
Appendix A: Model 2 estimation output

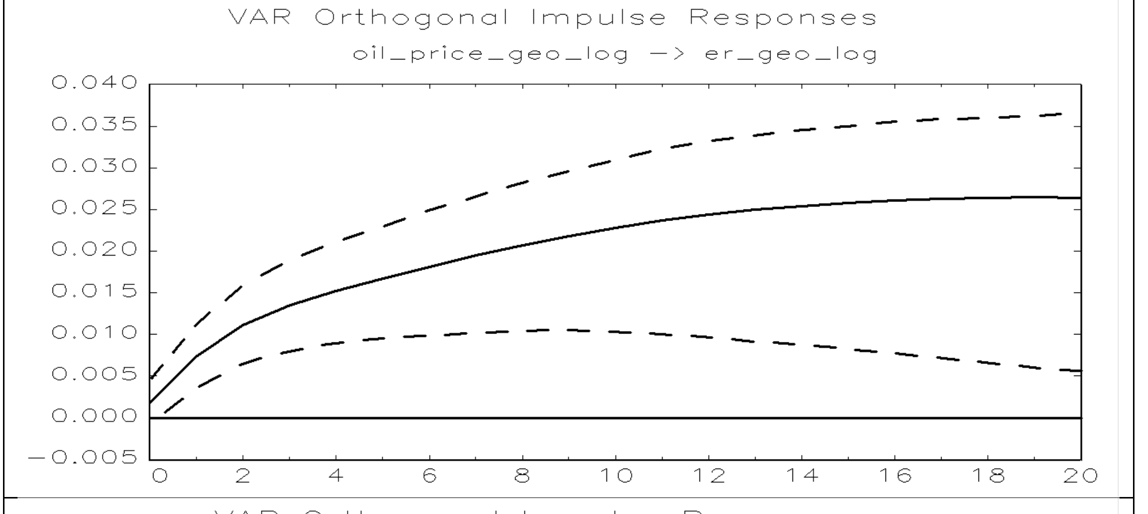
This section provides the results of impulse response functions estimation in Model 2 with first differences, logarithms and a dummy variable for the period of crisis in 2008, which were not presented in main part of the paper.

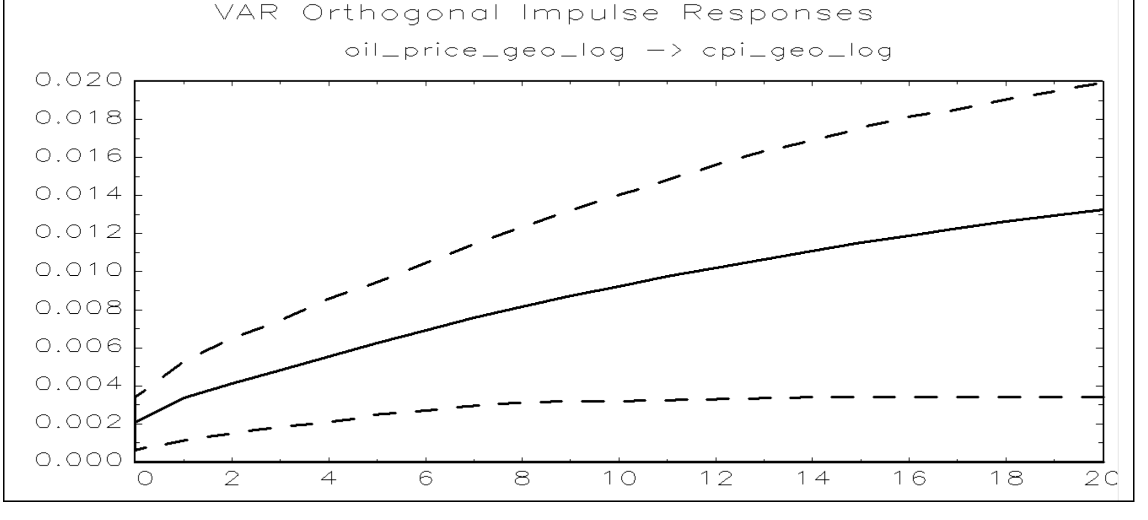
1. VAR orthogonal impulse response functions in Model 2 with dummy variable



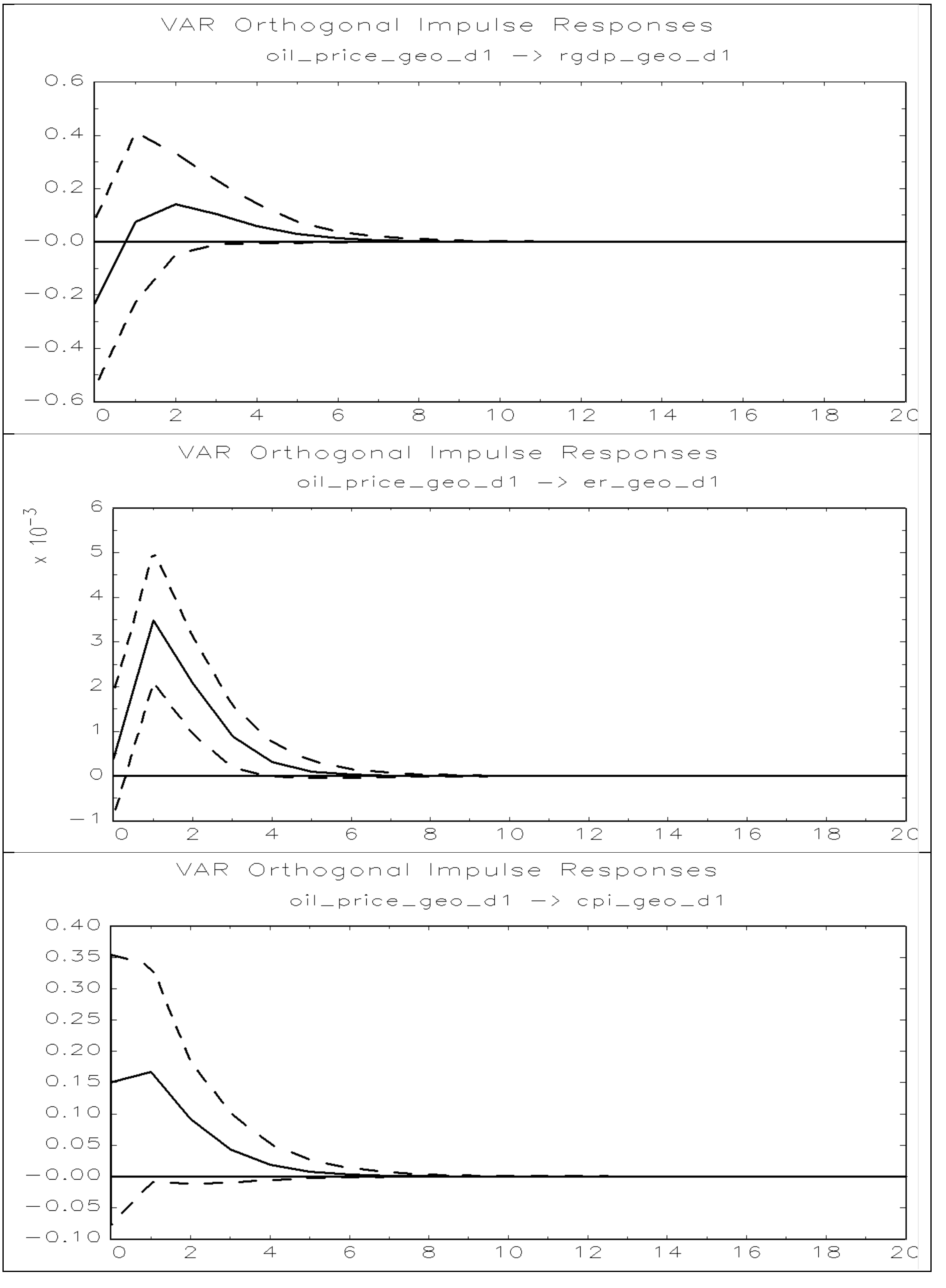
2. VAR orthogonal impulse response functions in Model 2 with logarithms







3. VAR orthogonal impulse response functions in Model 2 with first differences



Appendix B: Content of enclosed DVD

There is a DVD enclosed to this thesis which contains empirical data used in the estimation in the format of Microsoft Excel file.